POWER PLANT ENGINEERING

Established Over 31 Years

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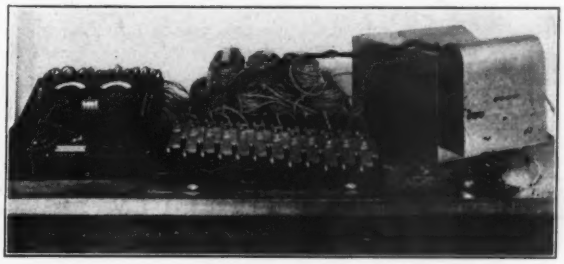


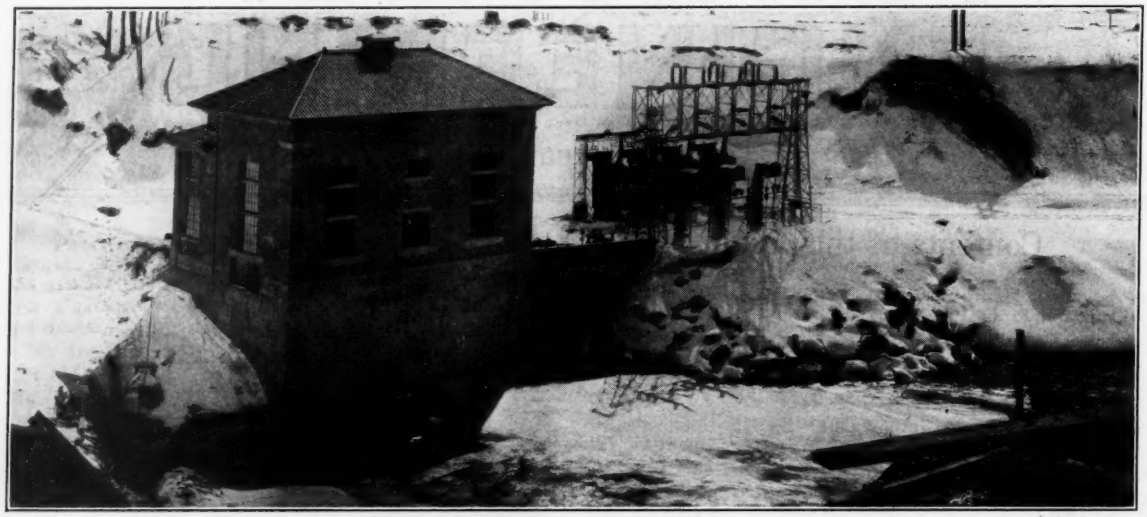
Portrait of a Unit Stress

WITH THE EQUIPMENT shown above, it is now possible to obtain a photograph that will show what the forces actually are in any member of a structure, whether they are as large as we had thought, whether they are in tension or compression, the amount and frequency of the vibration of the member—all recorded on a strip of photographic film and all procured from the member as it actually exists in a locomotive traveling a mile a minute, in the frame of an air craft or a ship, in a reinforced concrete structure and so on.

This instrument, called the Telemeter, permits obtaining as many as 12 such photographic records simultaneously. It was developed by Messrs. McCollum and Peters of the U. S. Bureau of Standards and after several years of use is being made available to industry.

In operation, the gages, shown in a row in the center of the photograph, are clamped to the member to be tested in such a way that knife edges will transmit any elongation or compression of the member through a lever to vary the pressure on two carbon resistor stacks which form the variable arms of a Wheatstone bridge. This variation of pressure changes the resistance and unbalances the bridge; this unbalance is indicated on a milliammeter or by an oscillograph from which a photograph can be made by the camera shown at the right. The instrument can be calibrated to read directly in pounds per square inch.

In the interesting and valuable work now under way on the Stevenson Creek experimental arch dam, shown elsewhere in this issue, Cartridge Telemeters embedded in the concrete have supplied extremely valuable data. They are also being applied to large steam turbines to measure vibration and stresses in the rotor and will probably have other important applications in power plant work.



Full Automatic Hydro Station at Sherman Dam

9000-KV.A. GENERATING STATION CONTROLLED AND OPERATED ENTIRELY FROM DAVIS BRIDGE STATION 2½ MILES AWAY. BY E. W. DILLARD[1] AND R. E. POWERS[2]

ON JANUARY 3, 1927, the New England Power Co. placed in service a 9000-kv.a. single unit, full automatic generating station which is considered a notable advancement in the application of full automatic control to large hydro-electric generating units. The station known as the Sherman Plant, situated on the Deerfield River in Monroe, Mass., is the second automatic station in operation on the New England Power System and is the largest single unit full automatic generating station now in service.

The hydro-electric development of the Deerfield River is probably as intensive as that on any stream in the country. Relatively large storage reservoirs permit close regulation of stream flow, and efficient use of water is necessary to economical operation. The present and future developments of the river are shown in Fig. 1, which illustrates clearly the relationship of the Sherman Station to the remainder of the system. Sherman is situated 2½ mi. below Davis Bridge Station, which has the largest storage reservoir on the Deerfield River, therefore being the gateway to the five lower plants which furnish nearly half of the kilowatt-hour output of the river. The storage available at Sherman is such that the Davis Bridge units can operate at full capacity during heavy load periods, meanwhile ponding water at Sherman. During off peak periods the Sherman unit will pass sufficient water to lower the pond to a point where the Davis Bridge units may again operate at full capacity during peak periods. The flow of water through the Sherman unit must be carefully regulated, so as to furnish sufficient water for the lower five stations for normal operation and for pondage to carry over peak load periods without loss of any appreciable quantity of water over the spillway at any station.

[1]Assistant Electrical Engineer, New England Power Co.
[2]General Engineer, Westinghouse Electric & Mfg. Co.

FIG. 1. MAP SHOWING LOCATION OF SHERMAN PLANT AND ITS RELATION TO OTHER STATIONS ON NEW ENGLAND POWER SYSTEM

The earth dam is a small replica of that at Davis Bridge and was built by the modified hydraulic fill method, all fine material being washed into a central pool forming an impervious core. The dam contains 300,000 cu. yd. of material and is 100 ft. high having a width at the base of 540 ft. The crest of the dam is 25 ft. wide and has a length of 720 ft. The completed dam covers 4.6 acres. Six steam shovels, five standard gage locomotives and about 40 large dump cars were used in the construction. The crest of the dam is 1139 ft. above sea level and the total drainage area is 234 sq. mi. A spillway channel 180 ft. long, located entirely in ledge, carries the overflow to the river bed below the dam. The crest of the spillway is 16 ft. below the top of the earth dam.

Water is taken to the power house through a 13-ft. penstock 225 ft. long and the intake is controlled by a 14-ft. structural steel Dow valve. The power house is of steel and brick construction, trimmed in cast stone with a Spanish tile roof and contains a single generating

unit. The unit consists of a 10,000-hp., 180-r.p.m. 78-ft. head reaction turbine manufactured by S. Morgan Smith Co., driving a 9000-kv.a., 2300-v., 60-cycle Westinghouse vertical generator. The unit is connected through a single 2300-v. bus to three 3000-kv.a. single phase, 2300 to 110,000-v. self-cooled transformers of the outdoor type. The transformers connect directly to a 110-kv., 2.3 mi. transmission line to the Davis Bridge station where it ties in with the New England Power System. An autovalve type, 110-kv. lightning arrester is installed on the line side of the transformer bank. Local service is not supplied by the Sherman-Davis Bridge 110-kv. line. There is a low capacity 2300-v. feeder from Davis Bridge to Sherman which is used as a supply for auxiliary power and lights when the station is not operating.

Because of the location of the Sherman plant it is necessary to have control of the unit at all times and to regulate the flow of water through the turbine in accordance with the demands of the system as a whole. The equipment is arranged so that operation of the plant is controlled directly from Davis Bridge. This has been accomplished by installing full automatic switching equipment in the Sherman Station, and extending the governor control circuits of the Sherman unit to the Davis Bridge plant. Thus the starting and stopping of the unit as well as its loading are controlled from Davis Bridge. A remote water level indicator at Davis Bridge records the Sherman tailwater level. The tailwater reading at Davis Bridge corresponds roughly to the Sherman headwater. Records of headwater and tailwater together with the known requirements of the system, determine the required steam flow through the Sherman unit. Inasmuch as the entire output of Sherman is transmitted to Davis Bridge a 110-kv. metering outfit at the latter point provides the operator with

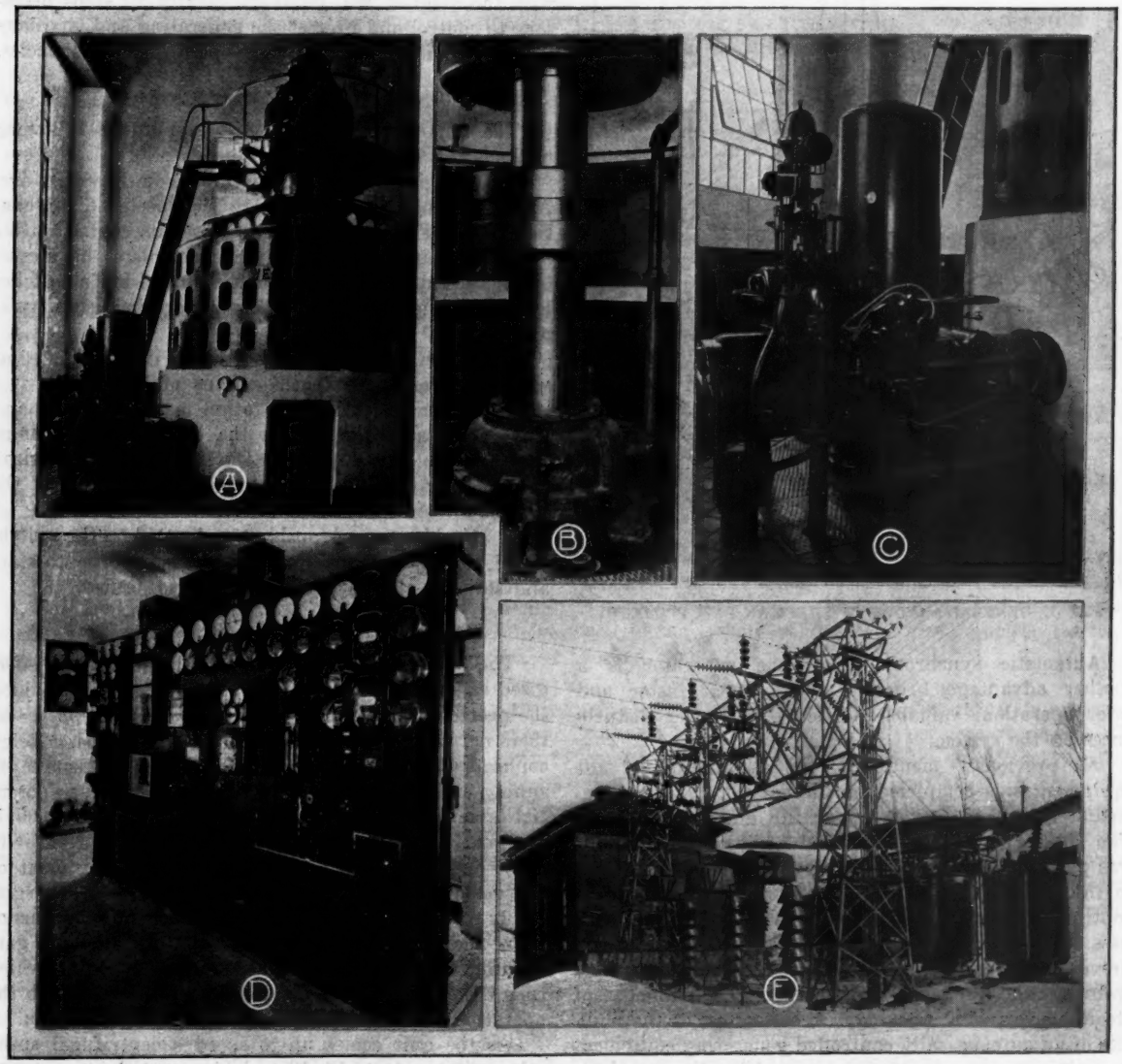


FIG. 2. VIEWS INSIDE AND OUT AT SHERMAN DAM. A. 9000-KV.A. VERTICAL GENERATOR, 2300 V. WITH DIRECT-CONNECTED EXCITER. B. SHAFT COUPLING AND GUIDE BEARING, SHOWING ALSO THE TEMPERATURE SAFETY RELAY ON WATER-WHEEL BEARING. C. AUTOMATICALLY CONTROLLED GOVERNOR. D. SWITCHBOARD WHICH AUTOMATICALLY CONTROLS 9000-KV.A. GENERATOR. E. POWER HOUSE, OUTDOOR BUS STRUCTURE AND TRANSFORMERS AT SHERMAN DAM

visual information regarding the kilowatt output, power factor, amperes, etc., from the Sherman Station. The plant is arranged to run (unless locked out by time switch) whenever the 110-kv. line is energized, and to shut down upon loss of load. Hence operating the breaker on the 110-kv. line at Davis Bridge starts or stops the plant. Besides the above advantage of flexibility and simplicity it is believed that the automatic equipment will show a material saving in operating cost. Under the present plan, the Sherman unit will be operating the entire day, which would require three shifts of operators under manual control. The automatic control scheme simplifies the problem of station attendance carrying with it the problem of securing suitable lodgings for the operators and their families for only one watchman will be required.

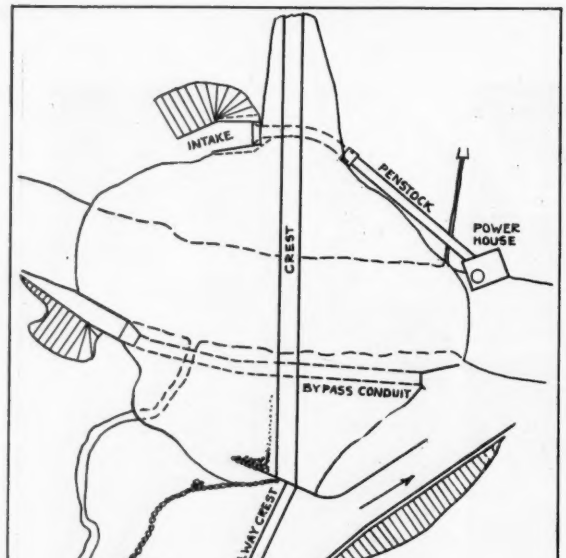


FIG. 3. GENERAL LAYOUT OF SHERMAN DAM PROJECT

Automatic synchronizing of the generator is a further advantage bringing about much faster and safer operation, valuable particularly during disturbances on the system.

As previously mentioned, the installation of the equipment was completed on January 3, 1927 and immediately put in service under full automatic control. The spillway was not completed at the time the unit was put into service, and as a bypass from the penstock to the tailrace was not provided it was essential that continuous operation of the unit be secured in order to pass sufficient water to run the lower five plants and to prevent the overflow of water through the incompleted spillway where a large crew of men and a number of steam shovels were working. A better test of the abilities of an automatically controlled generating equipment to meet severe service demands could hardly have been devised.

The scheme of automatic control and protection of the 9000-kv.a. generating and auxiliary equipment has been designed to afford reliable and satisfactory operation of the unit under any and all contingencies that may arise in normal operation and during periods of system disturbances. A number of the automatic features are rather unusual and a description of the equipment and its operation should prove interesting.

Switching equipment is arranged for either manual or automatic operation. Excitation for the generator may be supplied from the direct-connected exciter or from an auxiliary motor generator exciter. Control energy, for all relays and breakers closing mechanisms, is supplied from a 400-amp.-hr., 125-v. lead cell Exide storage battery. Thus a constant and reliable source of control energy is available at all times for correct relay operation and to close or trip breakers.

Figure 5 is a schematic and structural diagram showing all control circuits and relays together with a diagrammatic layout of all equipment in the Sherman Station. The following general description together with the diagram will point out clearly all steps necessary to control and protect the generating and auxiliary equipment under all conceivable operating contingencies.

Impulse to Start Unit

The unit may be started by any of the following methods:

a. Energizing of the 110-kv. line from Davis Bridge. An induction type voltage relay 1 connected to the station bus potential transformers closes its contacts after a predetermined time element to complete the circuit to the Master Relay 3 provided all control knife switches are closed and all protective devices are in their normal position.

b. Time Switch. A time switch the contacts of which are connected in the circuit of Master Relay 3 in such a manner that the station may be started and stopped in accordance with the time switch settings, provided the high line from Davis Bridge is energized continuously to energize voltage relay 1 during the periods of shut down.

c. Pushbutton. A pushbutton located on the switchboard affords a means of allowing an inspector to start and stop the station at any time he so desires.

Master Relay 3

The operating coil of Master Relay 3 will be energized as soon as the starting impulse is given, provided the protective relays 14, 66Y, 59X, 30, 63 and 66 are in their normal position. The closing of the Master Relay connects auxiliary bus BP-3 to the control source to supply energy to the control relays. As soon as potential is impressed on BP-3 the governor solenoid 65 is energized and oil pressure is admitted to the governor to cause opening of the turbine gates. The movement of the governor piston opens interlock 33 to de-energize the brake magnet to release the brakes. The governor opens the gates rapidly to approximately one-tenth gate opening to allow the wheel to start rotation, at which time the speed of gate opening is decreased through the operation of a dash pot on the governor mechanism.

As the unit comes up to speed a centrifugal speed relay with contacts 12, 13 and 14 mounted on an extension of the direct connected exciter shaft measures the speed of the unit. The centrifugal relay is so adjusted that its No. 13 contact closes at approximately 96 per cent synchronous speed.

Connecting Unit to the Line

The closing of the synchronous speed contacts 13 of the centrifugal speed relay completes the circuit to the auxiliary relays necessary to close the line oil circuit breaker 52. The closing of breaker 52 connects the unit to the line without excitation. During this period the unit runs as an induction motor.

Closing of Field Contactor

Auxiliary contacts, that close when breaker 52 is in the closed position, function to complete the circuit to the closing coil of field contactor control relay 41X which upon closing its contacts completes the control circuit to field contactor No. 41. The closing of field contactor 41 applies field to the generator, causing it to pull into step and supply load as the waterwheel gates continue to open to a value as determined by the governor pilot valve setting which is controlled from the Davis Bridge generating station. The governor has been given a fairly drooping characteristic, so that the generator will carry approximately a constant load.

It is interesting to note that the time required from the closing of the Master Relay 3 until the unit is on the line at full gate opening is less than 20 sec. The phasing in of the unit is accomplished by the self synchronizing automatic method and is performed so smoothly that fluctuations are not noticeable at Davis Bridge.

Load Control

To enable the Davis Bridge operators to have full control of the load carried by the Sherman Unit, suitable equipment was installed so that the speed control motor could be operated directly from Davis Bridge. Contactors 92X and 92Y are arranged so as to be energized over an auxiliary 3-wire control line from Davis Bridge. The closing of 92X or 92Y operates the synchronizing motor to change the governor pilot valve setting thus regulating for a new value of load. Indicating meters at Davis Bridge are used to indicate the kilowatt output at Sherman.

Protective Features

To obtain full protection to the generating and auxiliary equipment all conceivable contingencies have been taken into consideration. The relays that check the electrical and mechanical status of the high line and generating equipment are prompt and positive in their operation, allowing the equipment to remain in service to assist in carrying the system load to the full extent of the equipment ability but promptly functioning to take the unit out of service in case of trouble in either the generating, transforming or high line equipment. In the following is a list of the more important elements of the systems and their respective functions.

1. Oil Pressure Relay 63:

The unit is prevented from starting and shut down if running by an oil pressure relay 63 when the pressure in the governor oil pressure system drops below a predetermined value. The contacts of the relay are in series with the operating coil of master relay 3 and are closed only when the oil pressure is above 140 lb. per sq. in. Starting can be accomplished only when the oil pressure is again brought up to normal value.

2. Anti-Pumping Feature of Breaker 52:

Pumping of the machine breaker 52 is prevented by an anti-pumping relay 52Y the contacts of which short-circuit the operating coil of auxiliary relay 52X. The master relay must be de-energized before a reclosure of the breaker can be made.

3. Restart, Delay or Failure to Start:

Rapid restart of the unit due to failure of the oil circuit breaker to operate or to latch in, due to a faulty latch, is prevented by an auxiliary master relay 3X that begins its time cycle upon closing of the master relay. The time element of 3X is adjusted to cover a normal start at low headwater but with sufficient margin to take care of starting differences due to cold oil, etc. If breaker 52 has not closed within the time setting of 3X, its contacts will close to operate the lockout relay to shut the station down and lock it out. The 3X relay circuit is interlocked with machine breaker 52 in such a manner that closure of 52 opens the control circuit to 3X and stops its timing.

4. Field Failure:

A series type current relay is connected in the generator field circuit and is energized by the flow of field

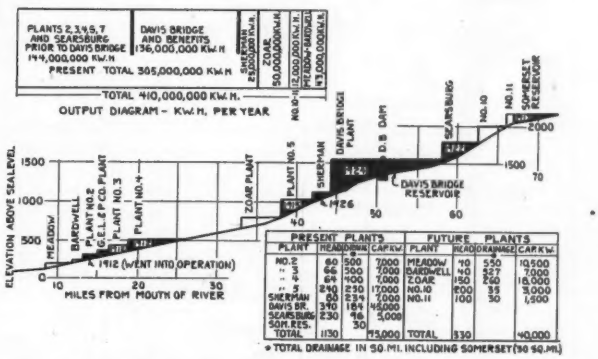

PLANTS 2,3,4,6,7 AND SEARSBURG PRIOR TO DAVIS BRIDGE 149,000,000 KW.H
DAVIS BRIDGE AND BENEFITS 136,000,000 KW.H
PRESENT TOTAL 305,000,000 KW.H
TOTAL 410,000,000 KW.H.
OUTPUT DIAGRAM - KW.H. PER YEAR
ELEVATION ABOVE SEA LEVEL
MILES FROM MOUTH OF RIVER
1912 (WENT INTO OPERATION)
DAVIS BRIDGE RESERVOIR
SOMERSET RESERVOIR
PRESENT PLANTS
FUTURE PLANTS
TOTAL DRAINAGE IN 50 MI. INCLUDING SOMERSET(130 SQ.MI.)

FIG. 4. NEW ENGLAND POWER SYSTEM, DEERFIELD RIVER DEVELOPMENT, SHOWING RELATION OF SHERMAN DAM TO SYSTEM

current. Any failure of excitation causes the relay to close its contacts to start a timing relay 62. If the field failure persists during the time element of the relay the coil to the lockout relay is energized and the station is locked out.

5. Overspeed:

The centrifugal overspeed device closes its overspeed contacts 12 at approximately 25 per cent overspeed. The contacts 12 of the overspeed device shunt the operating coil of the master relay 3 to shut the unit down temporarily. Rapid restart after overspeed is prevented by the underspeed contacts 14 of the speed relay that interrupt the circuit of the master relay 3 until the unit has decelerated to approximately 85 per cent normal speed at which time a restart may be made, provided all protective relays are in their normal position.

6. Differential Protection, 87:

Differential relays are operated from current transformers in the generator leads. Internal failure of the machine windings destroys the electrical balance of the relays and causes their operation. The operation of differential protective relays causes opening of the generator breaker 52 and field breaker 41, thus disconnecting the unit from the line and killing its internal voltage to prevent additional damage to the machine

windings. The closing of relays 87 also operates the lockout relay to prevent a restart until the cause of the lockout has been ascertained.

7. Overcurrent, 51:

Induction type current relays function on overcurrent to trip the line breaker 52, field contactor 41 and master relay 3 to shut the unit down.

8. Periodic Reclosing Relay, 66:

There is one feature of the automatic equipment that has been given attention that might be unusual though by no means necessarily limited to this installation. Balanced three phase voltage within 85 per cent normal value on the 2300-v. bus, will cause relay 1 to operate and close its contacts to supply the starting impulse. If one of the high tension circuits were to break, and fall well as at Sherman. The Davis Bridge breaker cannot then be successfully reclosed until the high line has been repaired and the short removed. In that case voltage will not be available at the 2300-v. bus to supply a starting indication at Sherman.

9. Creeping of Wheel Due to Leaky Gates:

Creeping of the wheel due to leaky gates is prevented by air operated brakes that are applied as soon as the governor mechanism has reached the full closed position. The brake magnet remains energized thus admitting air to the brake pistons until the governor again opens the gates a slight amount, roughly 3 per cent.

10. Discharged Condition of Battery:

An ampere hour meter is connected in the battery circuit to record the state of charge. Discharge of the

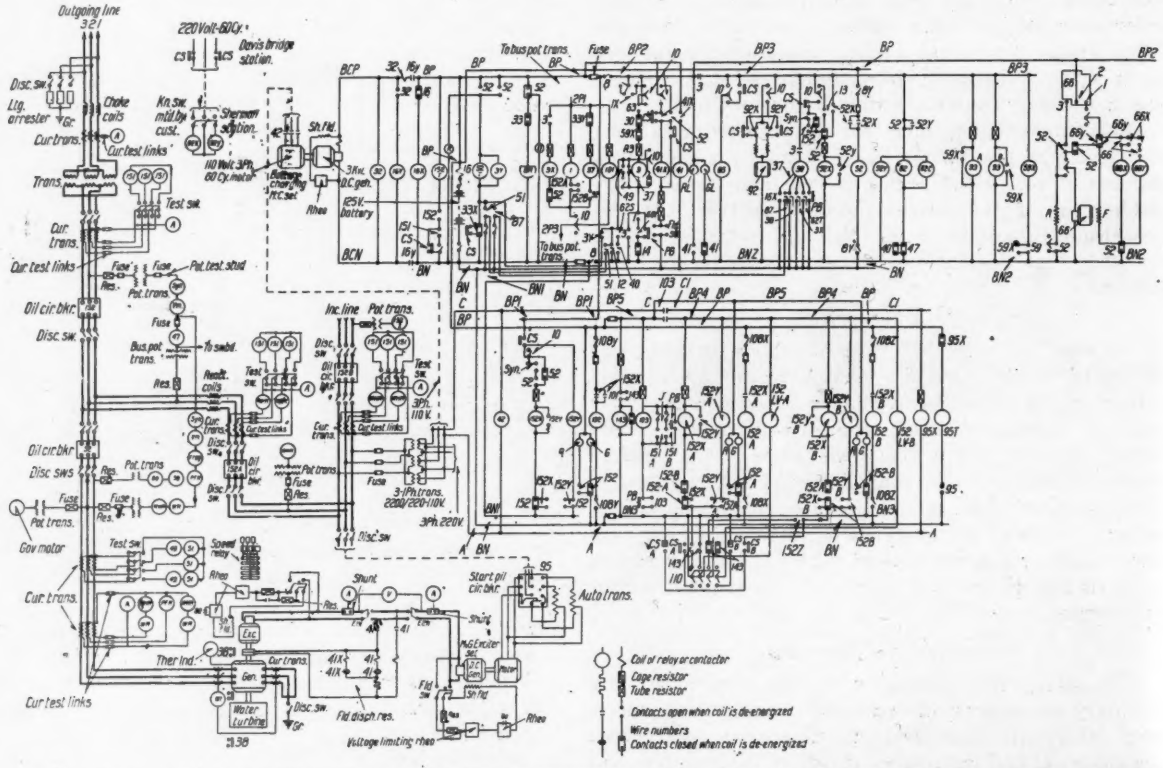


FIG. 5. ELECTRICAL CONNECTIONS OF EQUIPMENT AT SHERMAN DAM, SHOWING ALL RELAYS AND CONTROL CIRCUITS

in such a manner that the end nearest Davis Bridge were to swing clear of the ground, the Davis Bridge station could energize the high line and keep it energized, producing voltage on the 2300-v. bus at Sherman. Under such conditions Sherman would receive its starting impulse and close in on the line. With building up of the field the overcurrent relay 51 would again operate to shut the unit down. This cycle would be repeated unless an "anti-pumping" device were used to prevent this occurrence. A periodic reclosing relay 66 has been incorporated in the automatic sequence so that three restarts at two minutes interval can be secured before the periodic relay locks the station out by opening the 66 contact in the circuit to the operating coil of master relay 3. More usual short circuits, in which both ends of the high line ground, will not lock the station out, as the fault will open the breaker at Davis Bridge as battery to a point where satisfactory operation of the relays and breaker closing mechanism would no longer be secured will cause the contacts of ampere hour meter to close, causing lockout of the unit.

11. Spare Motor Generator Exciter:

Failure of the direct-connected exciter is provided against by the installation of an auxiliary induction motor generator exciter.

12. Low Voltage or Single Phase Operation:

Single phase or low voltage operation of the unit is prevented by a polyphase induction type relay that operates to energize time delay relay 62. The 62S contacts, of relay 62 in series with the closed or "make" contacts of field relay 40 will operate to shunt the operating coil of master relay 3 to take the unit out of service temporarily.

13. Temperature Detectors:

The generator has six exploring coils located in the winding so that the hot spot temperature of the machine can be readily secured through the use of instruments mounted on the switchboard.

14. Bearing Thermal Relays:

Bearing thermal relays are located in the Kingsbury thrust bearing and in the guide bearings. Should a bearing reach a temperature of approximately 95 degrees Centigrade the bearing thermal relay will operate to shut the unit down and lock it out.

15. Load Reduction Before Shut-down:

The switching equipment is so arranged that the load is ordinarily shifted from the generating unit before the line breaker is opened. The operation of any protective device, with the exception of overcurrent relay 51 and differential protective relays 87 operate to shunt the master relay, thus de-energizing the governor solenoid to close the gates to shift the load gradually from the station before opening the line breaker 52. Contacts on the governor mechanism operate to trip the breaker 52 when the governor has closed the gates to the no load running position.

16. Light Load Running:

The unit is removed from the line due to light load by an underload time delay relay 37 that is energized whenever the gate opening is below a pre-determined amount. The time element of relay 37 is adjustable and may be changed to meet the operating conditions. The unit will restart after being shut down on light load unless the high line to Davis Bridge is de-energized or the time switch contacts are opened.

17. Voltage Regulator:

A vibrating contact type of voltage regulator is used to maintain constant bus voltage. The contacts of the regulator are arranged so as to shunt sections of the exciter field rheostat. For any given bus voltage the rate of contact vibration is constant to provide an exciter field current suitable to produce proper average exciter voltage thus maintaining a constant alternating current bus voltage. Any change in alternating current voltage will either slow down or speed up the contact vibration to change the effective exciter field current to correct the bus voltage.

18. Generator Over-voltage:

Hydro-electric generating equipment is often subjected to momentary overspeed following system disturbances that result in tripping off a heavily loaded unit. The bus voltage will immediately be raised by an amount equal to the impedance drop in the machine windings and will continue to rise, due to increased exciter voltage and speed unless some external control equipment is used to prevent the voltage rise. As the

Facts of Interest Regarding Sherman Dam Project

Dam

Built by the modified hydraulic fill method. The fine material is washed into a central pool which forms an impervious core.

Height	100 ft.
Width of base	540 ft.
Width of crest	25 ft.
Length of crest	720 ft.
Elevation of crest above sea level	1139 ft.
Elevation of crest (Power Co. Datum)	1014 ft.
Drainage area (total)	234 sq. mi.
Drainage area (below Somerset)	204 sq. mi.
Drainage area (below Davis Bridge)	50 sq. mi.
Volume in dam	300,000 cu. yd.
Area covered by dam	4.6 acres
Number of steam shovels	6
Number of standard gauge locomotives	5
Number of large dump cars	40

Diversion Conduit

During the construction of the dam the river flow passed through a reinforced concrete conduit.

Length	425 ft.
Cross section area	141 sq. ft. (13½ ft. diam.)

Spillway

Concrete crest 16 ft. below top of earth dam. Waste channel below dam, located entirely in ledge, carries water back to river below dam.

Length of spillway	180 ft.
Capacity	35,000 sec. ft.

Pond

Area at elevation 1000 (Power Co. Datum)	209 acres
Highways rebuilt	2 miles
Highways discontinued	5 miles
Length of pond	2½ miles
Railroad relocation	2 miles
Cemetery moved	110 bodies

Intake and Penstock

Concrete intake and concrete conduit through earth dam. Water controlled by 14 ft. diameter structural steel disc arm valve.

Steel penstock length	225 ft.
Diameter	13 ft.

Power House

Steel-brick construction, cast stone trimmings and Spanish tile roof.

Dimensions	46 by 58 ft.
One unit	9500 hp.
Generator	9000 kv.a.
Mean head	78 ft.
Speed	180 r.p.m.
Voltage	2300 volts

Operation and Transmission

The station is automatically operated. It is regulated from the Davis Bridge Station 2½ miles away by means of three control wires.

Energy is stepped up to 110,000 volts and transmitted through the Davis Bridge Station to the System.

Contractors

Sherman Power Construction Company (Subsidiary of the New England Power Association).

Engineers

New England Power Construction Company.

Consulting Hydraulic Engineer

Albert S. Crane of the J. G. White Engineering Corporation, New York.

Equipment Contractors

Electrical equipment	Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.
Turbine and intake valve	S. Morgan Smith Co., York, Pa.
Penstock	Walsh's Holyoke Steam Boiler Works, Holyoke, Mass.
Crane (35 t.)	Northern Engineering Works, Detroit, Mich.

bus voltage rises suddenly, the regulator contacts will open to insert the full value of resistance in the exciter shunt field rheostat in an effort to maintain constant bus voltage. If the range of the regulator is exceeded, the voltage will continue to rise. If the voltage reaches approximately 130 per cent of normal, overvoltage relay 59, working through auxiliaries, opens the master sistance in the exciter field circuit to kill quickly the exciter voltage, consequently reducing the station bus voltage to a low value. The operation of over-voltage relay 59, working through auxiliaries, opens the master relay circuit to open the generator field contactor, thus resetting all control relays. The unit may restart again when it has dropped in speed to approximately 85 per cent of normal to reclose the underspeed contact 14 of the speed relay.

Auxiliary Station Control

In order to have energy available at the station during periods of shut down, a 2300-v., 3-phase, 60-cycle auxiliary supply line has been run in from Davis Bridge to furnish power for all station auxiliaries.

Oil circuit breakers 152A and 152B are equipped with an automatic transfer scheme so that the station service bus will be energized from the generator during operating periods and from the auxiliary 2300-v. line from Davis Bridge while the generating unit is idle.

Consider that the generating unit is idle and all control switches are closed for full automatic operation.

Oil breaker 152A will be open and the station auxiliaries will be supplied from Davis Bridge through breaker 152B. The impulse to start automatically the 9000-kv.a. unit is given by energizing the 110-kv. line from Davis Bridge. The station 2300-v. bus will then be energized up to breaker 152A, thus energizing the bus potential transformer, picking up induction type relays 1 and 101. The operation of relay 101 removes the contacts from around the operating coil of relay 143, allowing it to close. The closing of relay 143 open circuits the low voltage release coil of breaker 152B, causing it to open. Complete opening of 152B breaker sets up an interlock circuit to the auxiliary control relay of breaker 152A, causing it to close to re-establish full potential on all auxiliary equipment. The transfer from the 2300-v. station bus to the auxiliary line from Davis Bridge is accomplished in the reverse sequence when the 110-kv. line is de-energized by opening at Davis Bridge with consequent shutting down of unit due to light load.

Control Battery

The 125-v. Exide storage battery is given a trickle charge at all times from a small motor generator battery charging set that runs continuously, energy being supplied from the station 2300-v. bus or from the auxiliary 2300-v. line. The motor is arranged for direct across-the-line starting and is put on the line by the closing of contactor 42, the operating coil of which is energized continuously from a station service transformer.

The equipment at Sherman Dam has been in service since January 3, 1927 under full automatic control and has been regulating the stream flow and carrying a load of from 4000 to 6000 kw. Sufficient head to carry full load will not be available until flash boards can be placed on the crest of the spillway to raise the head to the required amount.

Pulverized Coal Furnace and Firing Problems

Unit Pulverizer Practice, Turbulent Burners, Drying Methods, Furnace Walls and Ash Pit Construction Are Matters for Study. By A. G. Christie*

INITIAL USE OF PULVERIZED coal as a fuel under boilers has increased during the last few years and improvements of extensive character have been made in all systems of firing so that better results are now obtainable than with the earlier installations. Still, new problems continue to present themselves.

Recently, there has been considerable discussion of central systems versus unit systems of firing. Without discussing the relative merits of the two systems or their comparative commercial efficiencies, which are the controversial points, certain comments on the developments of each system may be offered.

Unit Mills

Unit mills were first developed in small capacities and installed in small plants where costs of repairs and maintenance were not watched as closely as in the large central stations. Purchasers now demand better built and larger mills, which means that improvements must be made in the design of details of wearing parts, such as bearings, discs, casing liners and paddles. The latter should be of such form that they can be bought cheaply, should have long wearing life and should be quickly and easily replaced. Vibration and noise must also be reduced to a minimum.

One of the principal objections raised to the unit mill is that the degree of fineness often varies from the time a new set of paddles is put on until these are ready to be renewed. This introduces variations in furnace conditions and must have some effect on efficiency. It is hoped that the paddles of these mills can be so designed as to give more uniform fineness of product during their life.

A distinct advantage of the unit mill, especially where preheated air is available, is its ability to burn almost any coal without previous drying, which simplifies the installation and improves the boiler room layout. The trend in burner design for unit mills will be towards mixing burners, which will produce the greatest amount of turbulence, and which will provide for the admission of all combustion air with the fuel at the burners. A problem that does not appear to have been satisfactorily solved is the prevention of possible flame propagation from the burner back into the mill when shutting down. This needs further study by designers.

How many unit pulverizers should be installed per boiler? Not less than two for reliability but, if both these are of such capacity to supply the maximum requirements of the furnace, then a large reserve capacity will be carried. If each is of half the maximum requirements, then boiler capacity is lost when one stops. It

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has been suggested that unit mills be made in one small standard size, which could be easily removed and replaced, each to supply its own burner and as many placed on each boiler as are needed for the required output. Such standard mills could be manufactured in quantity at low cost. A few reserve mills would cost little and could quickly replace any that fail. This suggestion appears to have certain advantages and may prove an economic solution of the problem.

Builders of the central systems have been slow in adopting mixing or turbulent burners. As a result, furnace volumes have been large, settings high and boiler houses expensive. When highly preheated air is used, it becomes desirable to employ a short turbulent flame since ignition is more rapid. Besides, increased furnace temperatures are making the maintenance of air-cooled front walls more difficult. Hence, the trend towards the use of water-cooled front walls and to mixing burners.

Coal Drying

Coal dryers are still a much debated problem. At present, the best equipment for drying appears to be the rotary dryer but this takes much room and consumes an appreciable amount of fuel. Most of these dryers are fired under the upper end where the raw coal enters, flue gases entering the lower end, passing up through the coal and out at the upper end. Many years ago the writer designed some coal dryers which were fired under the lower or coal discharge end. The gases entered the dryer at the upper end where the raw coal entered and passed out at the lower end. Large Z bars were riveted to the inside of the shell to stir up the coal as the dryer rotated. The advantages of this design were that the shell was hottest where the coal should be driest, the cold, wet, entering coal immediately met hot gases and was more quickly raised to the wet bulb temperature of the gases at which evaporation took place and, finally, excellent drying was secured in service from a relatively short dryer. The only trouble was a dust nuisance from the highly dried coal but no attempt was made, in this particular cement mill, to recover this dust by a cyclone or any other device.

Waste heat dryers using flue gases, have proved reliable and satisfactory in many plants but steam dryers have not been quite so successful. The attempts now being made to dry the coal in the mills by admitting preheated air will be watched with interest.

All these dryers are expected to remove the so-called "surface" moisture as it has been found unnecessary to remove inherent or combined moisture to secure good pulverization. In many industrial processes, surface moisture is removed by centrifuges, employing centrifugal force. It is possible that the surface moisture may yet be removed from coal by a similar process. In fact it is rumored that such a plant has already been developed and has operated satisfactorily but no description of the plant or data on results have been made public at this writing.

Large sized mills now used in central systems have shown some reductions in power consumption. One wonders whether all the possibilities of stage pulverization have been completely explored. For instance, at present coal is delivered to Fuller or Raymond mills in sizes varying from ¾ to 1¼ in. It is known that the capacity of these mills is about doubled, if coal of ¼-in. size is furnished to them. In rock crushing practice, when two-stage crushing is employed, the fines are screened out between crushers, thus relieving the second crusher of considerable tonnage. This plan might be used to relieve the pulverizer of handling coal already reduced to the necessary fineness in the preliminary crushing. How does the total power consumption per ton for crusher and pulverizer compare under these two conditions? It has been claimed that the combination with ¼-in. coal to the pulverizer uses less power. What are the facts as established by actual test?

Furnace Construction

In furnace design, the trend is towards the development of more B.t.u. per cubic foot of furnace volume, which is equivalent to providing a smaller furnace for a given boiler output. Designers now talk of rates of combustion of 30,000 B.t.u. per cubic foot of furnace volume. This rate of combustion can only be secured with uniformly ground coal, thoroughly mixed in a turbulent flame with the necessary combustion air, which should preferably be highly preheated. Such a flame will have a high per cent of CO_2 and will develop a high furnace temperature so that special provisions must be made to maintain the furnace walls.

Character of the furnace walls is influenced by the type of coal to be burned, the nature of its ash and the furnace temperature desired. Anthracite and certain coals with ash of high fusing temperature, are burned satisfactorily in furnaces with refractory walls. It has been the experience with most coals that boiler capacities are limited to about 300 per cent of rating when air-cooled refractory walls are used. If higher operation at high CO_2 is attempted, the brickwork starts to run. On the other hand, water-cooled walls have been used on boilers up to 500 per cent rating and this does not appear to be the limit that such walls will stand.

These matters of possible capacities and the combined boiler and furnace efficiencies at these capacities are matters of considerable economic importance to engineers. Continuous operation of boilers at high output and high efficiency reduces the number of boilers needed to deliver a given amount of steam, which is one method of reducing boiler house investment. The cost of auxiliaries increases somewhat but, on the whole, a substantial reduction of plant investment may be effected by operating at such high output. This has led to the plan of providing one boiler per turbine even in large stations. In fact one new central station has gone into operation where a boiler with 29,000 sq. ft. of heating surface (including water-cooled walls) will provide steam for a 36,000-kw. turbine, the plant operating successfully under these conditions. Increased furnace and boiler capacities at high efficiencies are, therefore, factors which may have great significance in future attempts to reduce the fixed costs per kilowatt of installed capacity.

Experience with the various types of water-cooled furnace walls has not been sufficiently extensive to permit any broad conclusions regarding their relative merits. The early form with water screen tubes in front of the brick refractories developed definite faults

with certain coals. On the other hand, the recessed tube construction with brick refractories is showing satisfactory performance in various plants and is low in first cost. The Murray fin type, the Bailey wall and the radiant energy side and rear wall superheaters are all in use and seem to be able to meet the most severe conditions.

In these last three types the wall consists essentially of long tubes, often with bends at both ends for flexibility, backed up by insulating material and usually with a metal casing. In powdered coal furnaces, slight explosions are not unknown. What will be the effect on these large flat wall surfaces of relatively small increases in pressure in the furnace? Such large unstayed surfaces with connections of a flexible nature will respond to slight changes of interior pressure and may tend to bulge. This may affect the holding power of the tubes, if often repeated, hence, these walls may require extensive stay bracing and stiffening to resist such contingencies.

Objection has been raised to certain forms of water walls on the basis that the cold furnace causes much smoke in starting up and at very light loads. It is also stated that this trouble is less noticeable when extensive refractory areas form a part of the furnace walls. This brings up a problem in regard to the amount of refractory surface needed. The writer's opinion is that the difficulty with smoke is largely due to the type of burners used. If the final mixture of preheated air and coal enters at the burners with sufficient turbulence, combustion will be rapid and the mass-effect of this flame will be modified only slightly by any surrounding water walls, so that little smoke should occur. Further developments in combustion equipment will be needed to indicate whether or not refractories should form a part of furnace walls and if so, what proportion of the walls.

Ash Treatment

Ash pits of some of the first plants to use powdered coal were constructed with a water screen above them. This screen consisted of a series of sloping tubes on about 10½-in. centers. In falling through this screen, the ash particles were cooled and were supposed to collect in the ash pit as a dust. These conditions existed if the flame did not penetrate the screen but that rendered the large volume of the furnace below the water screen inactive for combustion. At heavy loads, the flame would penetrate the screen and slagging on the tubes and in the ash pit generally resulted. Also the furnace bottom would tend to overheat. A remedy for these conditions appears to be the use of cast-iron-faced, water-cooled ash pits built in the form of a V. The whole furnace volume will then be available for combustion and slagging conditions may be prevented, or at least greatly reduced, by such an ash pit construction.

Engineers who desire to use high rates of combustion in relatively small furnaces will have to face the question of whether a fine granular ash or a fluid ash is desired. A water-cooled bottom will tend to produce the granular ash but, if this has no utility, it may be less desirable than a fluid ash which would form in a refractory-lined bottom. Slags from blast furnaces are said to be cast into building and paving blocks abroad. Possibly some such use might be developed for liquid slags from powdered coal furnaces. Another use might be in the form of cinder for cinder-block concrete now widely used for stucco house construction.

Use of pulverized coal under large boilers extends over comparatively few years. Remarkable progress has been made during this time and also in the design of boilers, furnaces, air heaters and other plant equipment. New ideas have also been applied to stoker plants as well, so that the performance of modern stokers of large size has shown great improvement. If pulverized fuel is to find still wider application, designers of the various systems must strive after still higher economy and to make it possible to offer lower priced equipment, so as to reduce the total boiler plant investment for a given output at a stated high efficiency. These notes have pointed out certain factors in these problems for both builders and users and have, in some cases, suggested possible solutions to the problems still before engineers.

Summer Work

NOBODY likes to work too hard in summer and overhauling is always a more or less unpleasant job. We all know it but we also know that, unless such work is done when needed and preferably before the need is actually felt, penalty will be paid in rush repairs or even in shut downs.

Summer is the time when power demands are usually light and heating plants shut down. It is the time for putting things in best possible shape for the heavy demands of next winter. Peace of mind comes with keeping two jumps—or more—ahead of requirements.

Early overhauling is desirable because it remedies defects which have developed during the past season, makes operation for the rest of the summer easier and is done while experience of the last winter's troubles is fresh in mind. It should be done with a view to avoiding those troubles next winter. Changes to remedy defective circulation, troubles from leaks, packing and condensate discharge can be made now without disturbing operation. Back pressure and control valves can be reconditioned and relocated so as to give most effective and convenient control. Traps, pumps and receivers should be put in shape for best performance.

While condition of the power house structure may not seriously affect plant operation, it must be kept up to the mark if cost of operation is to be a minimum. Roofs need special attention, that they be cleared of dirt and debris; that any cracks be repaired; that tin roofs be painted if needed (at least every 3 yr.) and bad spots touched up; that down spouts be cleared so as to carry away rainfall freely. Skylights need a coat of paint every year, window sash every 3 yr., exposed piping and sheet metal work every 2 yr.

Brick work, especially cornices, parapets and chimneys should be painted if mortar shows signs of loosening.

Summer overhauling will not take the place of regular inspection and repair during the year but a thorough going over of the plant will reduce the work required during the heavy load season. Conversely, repairs should be made promptly, when needed during that season, as this will reduce the work required during the summer overhauling and leave more time for fishing, motoring or golf.

High Pressure and Temperature at Crawford*

STATION FOR 550 LB. AND 725 DEG. USING ILLINOIS COAL WITH HEAT VALUE OF 10,255 B.T.U. STAGE BLEEDING, REHEAT AND AIR PREHEATING UTILIZED. BY ALEX D. BAILEY**

DESCRIPTION of the Crawford Avenue Station has been given in Power Plant Engineering, the original installation consisting of a 50,000-kw. unit built by Parsons Co. of England, a 60,000-kw. unit built by the General Electric Co. and a 50,000-kw. unit built by the Westinghouse Co. No. 4 unit is of 75,000 kw. built by the General Electric Co. and No. 5 is 90,000 kw. built by the same company. No. 6 unit, which is now on order, is of 100,000 kw. to be built by the Westinghouse Co. The first three units were put into operation late in 1924 and in the spring of 1925. No. 4 unit was put into service in August, 1926, No. 5 will be put in service in August, 1927 and No. 6 in the summer of 1928. In his paper Mr. Bailey detailed some differences in the units and why these differences were introduced.

POSSIBLE SAVINGS AND COSTS

Crawford Avenue is the latest undertaking of the Commonwealth Edison Co., another step in the direction of higher steam pressure and temperature, in line with the progression which the company has made in constructing its various stations. Decision to use 550 lb. and 725 deg. F. rather than a higher temperature was made because, at the time Crawford Avenue Station was conceived, 600 to 650 lb. was the limit for riveted drums and for standard types of boilers. Also turbine manufacturers did not care to consider higher pressures for units of the size contemplated and, at that time, the advantages of steam at higher pressures were not definitely proven and its properties were more or less hypothetical. As compared with the company's Calumet station, the increase in steam pressure meant a saving of over 5 per cent, the increase in temperature 2½ per cent and that due to reheat about 5½ per cent, also there was 2½ per cent saving by stage bleeding. These gains in a station the size of Crawford, which uses some 95,000 t. of coal a month, were well worth while. At all points, however, the question of thermal saving was figured in connection with the real dollars and cents economic advantage and the effect of cost of installation on overhead was carefully considered. Comparison of the Calumet and various Crawford installations shows that for the turbines the cost at Calumet per kw. was $27.46, for the Nos. 1, 2 and 3 units at Crawford, $29.38 and for No. 4 unit at Crawford, $23.33. For the boiler equipment the costs were, Calumet $40.00, Crawford, 1, 2 and 3 units, $43.25, Crawford unit No. 4, $32.13. Building cost for Calumet was $34.21 per kw. and for Crawford $30.20.

Comparison of the performance of the various installations is shown in Fig. 1, curve A being for the Calumet units Nos. 1 to 6, B for Crawford Avenue units 1 to 3 without reheating, C for the same units with reheating and D for Crawford unit No. 4 which has no reheating. Conditions of operation were: for Calumet 300 lb. initial pressure and 1 in. vacuum with 225 deg. superheat on units 1 and 6 and 228 deg. on units 2 to 5. For Crawford, initial pressure is 550 lb., vacuum 1 in., the initial superheat actually used for No. 1 unit 270 deg., for Nos. 2 and 3, 245 deg. and for No. 4, 270 deg. Reheat temperature at Crawford was, for units 1 and 3, 700 deg. and for unit 2, 725 deg., unit No. 4 having no reheating.

REHEAT VS. OVERHEAD AND CAPACITY

It has been found that as far as blades, wheels, packings, casings and other details are concerned, high pressure and temperature have caused no turbine trouble. In fact the cases have been tighter than with some of the old 200 lb. installations.

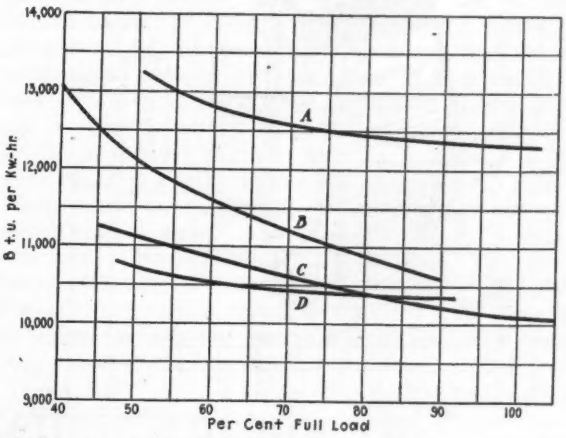


FIG. 1. HEAT CONSUMPTION OF TURBINE UNITS AT CALUMET AND CRAWFORD AVE. STATIONS. A, CALUMET. B, CRAWFORD UNITS 1 TO 3, NO REHEAT. C, UNITS 1 TO 3 WITH REHEAT. D, UNIT 4

The reason for omitting reheat in unit No. 4 was because when it was purchased, it was understood that the load factor would be lower than that for the previous units, that it would probably be shut down nights and that its use would largely be to carry part of the system reserve. Effort was therefore made to obtain the greatest possible capacity in the space allowable and to simplify equipment as much as possible so that variations in load could be taken care of and would affect the thermal efficiency as little as possible. Reheat was not omitted because of trouble with the reheating boilers of units 1, 2 and 3, since those boilers have been unexpectedly free from operating difficulties.

For unit No. 5, now being installed, a lower degree of reheat is provided by means of live steam, as this involves an investment about ¼ that for boiler reheating and the saving, even at reduced load factor, justifies the investment. Saving by steam reheating is only 3 per cent, as compared with 5½ per cent for boiler reheating but, in addition to the less first cost, the building space requirements are much less for the steam reheating.

Circulating water at Crawford is exceedingly bad, containing not only sewage and dirt, but a great amount of organic matter which solidifies on being heated and

*From a paper presented at the Spring Meeting of the A. S. M. E.

**Supt. generating stations, Commonwealth Edison Co.

effectively blocks the tubes. Vertical condensers with the tubes rolled into the tube sheet at one end and packed at the other have worked well and because of the ease of cleaning have been a great convenience. The company has experimented with chlorine treatment and has obtained some encouraging results, as it appears that this treatment will prevent, or at least retard the formation of slime in the tubes and on the tube sheets. As to tightness, these condensers have given better results than any previous installations, leakage being reduced to a minimum, the rolled joints giving no trouble whatever, and the various types of tube packing all having been effective.

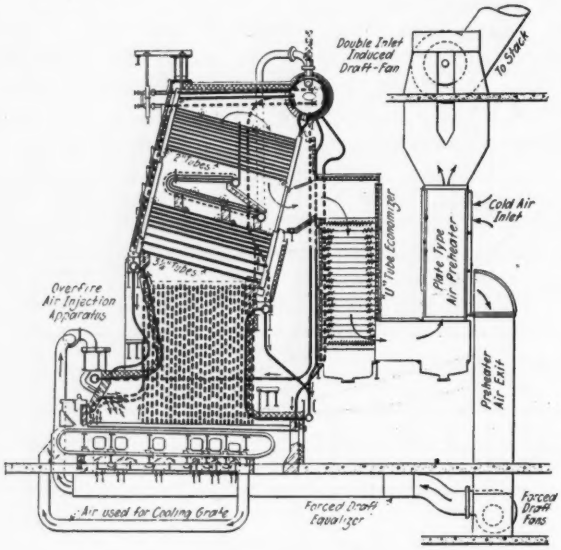


FIG. 2. SECTION OF BOILER NO. 5 OF UNIT NO. 4 AT CRAWFORD AVE. STATION

Boiler feed pumps, which were of four-stage type with split cases running at 3600 r.p.m., gave some trouble for a time, due to leakage between stages and thrust bearing difficulty but these were soon remedied. For the 4th and 5th units, however, a six-stage pump, running at 1800 r.p.m. has been adopted, water for these pumps coming from a condenser through the bleed heaters and to the pump suction at about 20 lb. pressure. For the original installation, turbines were bled at three points, while unit No. 4 has four bleed points. Packing failures in the bleed heaters gave difficulty at the start, but a moulded asbestos packing has been found which eliminates this difficulty, which could not, however, be charged to high pressure, since, at the bleed stages, the pressures were moderate or low. Piping has given little trouble, except that in service defects appear in the steel castings used for fittings and, while it is possible that the X-ray method of testing would detect these faults, that has not been considered practical for so large an installation as Crawford Avenue.

Real difficulty has been found because of the high sulphur content in the coal and the high amount of ash. The coal used has 12.7 per cent ash, 14.5 per cent moisture and 3.86 per cent sulphur so that any moisture collecting upon the boiler surfaces is immediately converted to sulphuric acid, also the large amount of ash has a comparatively low melting point which is deposited upon the tubes and surfaces and produces clogging unless quickly removed. The high percentage of moisture and 4 per cent hydrogen result in a high stack loss.

To prevent slag from running down onto the grates and eliminate the slicing of fires, a limited amount of water-cooled surface was tried in the furnace walls at Calumet about 3 yr. ago and proved so satisfactory that the two boilers of unit No. 3 and all subsequent installations at Crawford have been water-cooled. Figure 2 gives a cross-section of the No. 5 boiler on unit No. 4 at Crawford Ave. which, as will be seen, has water-cooled furnace walls with a "U"-tube economizer and plate type of air preheater. There seems to be a limit to the amount of water-cooled surface which can be profitably installed in furnace walls as, if it is overdone, ignition of the coal is retarded and final burning out of the coal is delayed. Apparently the boiler equipped with a refractory lined furnace gives best efficiency but, to maintain the high capacities necessary without excessive cost for maintenance of the furnace, a compromise has to be made and the furnace enclosed on three sides with water tubes alternated with rows of refractory. A refractory arch wall is also used. None of the water-cooled furnaces has given any trouble.

With chemically treated feed water, it was found that, when boilers operated at high capacities, dirt was carried over to the steam lines and into the turbines where it deposited on the turbine screens and the initial nozzles. Recently an evaporator has been installed for furnishing all make-up water, which it is hoped will take care of the trouble referred to.

Considerable trouble has been experienced from slag which is carried up with the gases and lodged between the tubes; because of the reduced tube spacing, this difficulty was worse at Crawford Avenue than for previous installations. This accumulation could not be readily blown off with steam and attempts were made to crack it off with a fine water jet but it was found that this loosened the tubes in the rolled joints, so it became necessary to rely on steam blowers for cleaning.

Auxiliary equipment has given little trouble. The safety valves, which it was thought might bother, have performed creditably and feed water regulators have gone along fairly well, although their work has been reduced by the installation of differential pressure regulators ahead of them in the feed line to each boiler.

SUPERHEATERS AND ECONOMIZERS

For the first installation, superheater surface in the boilers was restricted more than necessary in order to guard against excessively high steam temperatures. This, together with fouling of the tubes externally has resulted in temperatures somewhat below those specified but additional surface is now being added to take care of this deficiency. When the amount of steam put through the superheaters was reduced, some difficulty was found with burning of superheater tubes, particularly in the reheat boilers but there were seldom, if ever, any deposits found in the tubes and it is thought that the burning was due to short-circuiting of steam to some of the tubes, leaving some of them empty. Installation of steam baffles in the superheater boxes is helping the situation.

Reheat boilers have developed no trouble but the anxiety to avoid overheating steam resulted in a lack of surface and a deficiency of about 50 deg. has been found in the reheat.

Because of the great amount of sulphur in the coal, it is important that moisture does not enter the flue gas passages and with the economizers as first installed, this made considerable trouble. Mechanical strains set up in the joints where the tubes were rolled into the boxes, caused minute leakage and this combining with the sulphur produced sulphuric acid, which resulted in rapid deterioration. After one and one-half to two years of service, this leakage became serious and, in order to overcome it, the economizer for the fourth unit had the boxes eliminated at one end, the tubes being bent in hairpin form and the open ends rolled into boxes similar to the original installation. A baffle plate was put in front of the boxes so that flue gases did not come in contact with the joints there. In the final installation, the No. 5 unit, the economizer consists of straight tubes with return bends bolted on the ends, the tubes being supported in cast-iron plates and the openings packed so that the flue gas cannot get at the joints. As it is around the joints that the main difficulty has been experienced, it is expected that this will prolong the life of the tubes over a period of several years, also manufacturers are now experimenting with the use of enameled tubes as a means of reducing corrosion.

In the older plants, air preheated up to 190 deg. has been used, but in the Crawford Avenue installation, 300 deg. air was introduced under the chain grate stokers. This caused some difficulty with heating of the chains, resulting in burning of links and uneven fires, which has been remedied by cooling the chain on its return passage and by water-cooled drums at the rear of the stoker. It is anticipated that, with these provisions, temperatures up to 400 deg. can be used.

In conclusion, Mr. Bailey stated that the problems at Crawford Avenue have been the same ones, or of a similar kind to those encountered in older stations and he sees no reason why still higher pressures cannot be used, if they prove economically advantageous and the materials for handling them become available. It is generally agreed, however, that gain resulting from increased pressure decreases as pressure increases, until a point is reached where increase in fixed charges overcomes the savings effected in operation. The thing to be sought is best possible service at lowest possible cost and this depends on investment cost as well as operation. Under the conditions at Crawford Ave., at 60 per cent capacity factor, fixed charges per ton of coal burned amount to slightly more than $3 for each $100 investment cost of the unit. This means that an increase of 10 per cent in investment cost must result in fuel saving of approximately 9 per cent of operating cost in order to be justified or, in other words, $1 added to the investment cost per kilowatt installed has the same effect as adding 3c per ton to the price of coal. Hope for reduced investment cost lies in a high capacity factor and, if higher steam pressure and temperature will help to accomplish this end and also give additional operating efficiency, the way is clear. If, however, the two run in opposition, each of them must be carefully studied, the emphasis being placed always on the investment side of the argument.

Is It Necessary to Renew Turbine Oil?

System of Turbine Oil Reconditioning as Used at the Acme Plant of the Toledo Edison Co. Proves Satisfactory. By S. S. Dougherty*

THIS QUESTION is a pertinent one and is no doubt answered differently at various turbine operating plants. When operating turbine units of 10,000 kw. capacity and upward, however, there is in many cases an operating item in the order of thousands of dollars annually to be considered.

In many cases 500 gal. of turbine oil is dumped or sold for a few cents a gallon because it is getting old and discolored rather than because it is really unfit for use. Even in plants taking periodic samples for laboratory reports, the person ordering the oil changed probably does so because he would rather be safe than sorry instead of because he actually knows the oil is unfit for use.

In some of the modern plants guesswork has been eliminated and the oil kept in good condition by a reconditioning process consisting of passing a stream of warm oil through a spray of cold water, to form an intimate mixture. This mixture is then passed through a muslin filter into a settling tank with a heating coil where the mixture is heated to about 175 deg. F. This temperature is maintained about a day after which the heat is turned off and the settling process allowed to continue four or five days longer. The oil is then drawn off the top of the tank by means of a floating suction pipe and is passed through a centrifuge on its way to the clean storage.

At the Acme Plant of the Toledo Edison Co. the system is installed as shown in Fig. 2. This system is slightly more complicated than a new system might be, but in this particular case it is a rearrangement of two or more old systems. The only new pieces of equipment purchased for this layout were the sight overflows for the turbines, the bag filter and the floating suction for the settling tank.

To prevent the draining of oil from a turbine by carelessness or malicious intent, a section of the drain line is made removable by unscrewing two unions. Normally this section of pipe is removed and it is only inserted when the turbine is to be drained.

Such serious and costly damage may be done to a turbine by the loss of oil level, that this inexpensive precaution was thought advisable. The principal idea of the device is that if the drain valve should be opened accidentally the flowing of the oil out onto the turbine room floor would immediately attract attention. A malicious attempt to drain the oil would necessitate the fitting in place of the removable section of pipe which could not easily be done without attracting the attention of some one in authority.

Normally the method of operation is to drain the

*Detroit Edison Co., formerly with Toledo Edison Co.

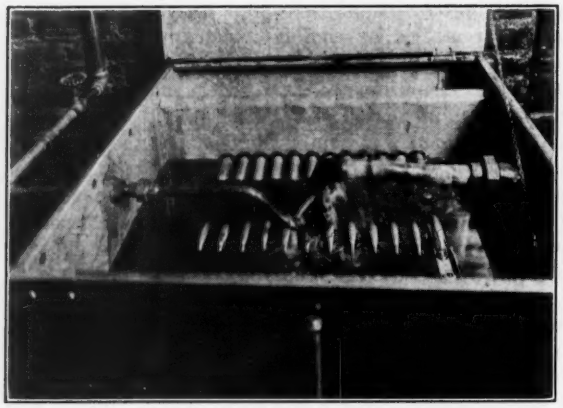


FIG. 1. OIL COMES IN THROUGH THE UPPER PIPE AND WATER THROUGH THE LOWER PIPE TO GIVE AN INTIMATE CONTACT BETWEEN THE TWO FLUIDS

turbine when it is shut down for some other purpose. The rate of flow used is about 100 gal. per hour, thus requiring from six to eight hours to pass the water wash and filter. The proportion of water to oil is approximately one to three; however, the overflow on the settling tank is so arranged that the water will flow to the sewer automatically if there should be such an excess of water as to bring the level of the oil nearly to the top of the tank.

If the turbine is to be shut down for only a short while the oil is allowed to flow immediately to the emergency tanks and the turbine is refilled either from the overhead tanks direct or by pumping up from the clean oil storage. Then, as convenient, the oil that has come down from the turbine is pumped from the emergency tanks to the reconditioning system.

Oil Can Be Changed While Turbine Is Operating

If it is desirable to change oil in one of the turbines without shutting it down, it is easily accomplished. Fresh oil is let into the turbine slowly, thus causing oil from the turbine system to overflow at the sight overflow. This overflow oil flows to the water wash and thence to the settling tank. When the settling tank is filled, the operation is either discontinued until the batch can be treated as usual, or the overflow from the

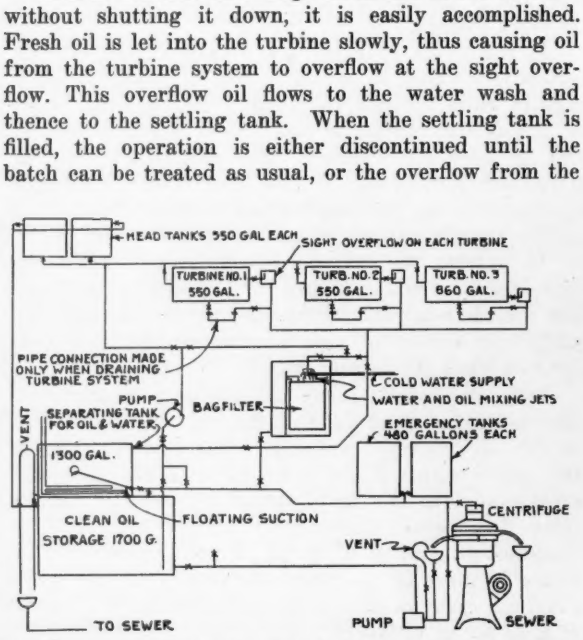


FIG. 2. IN THIS SYSTEM THE OIL FLOWS THROUGH THE PROCESS BY GRAVITY

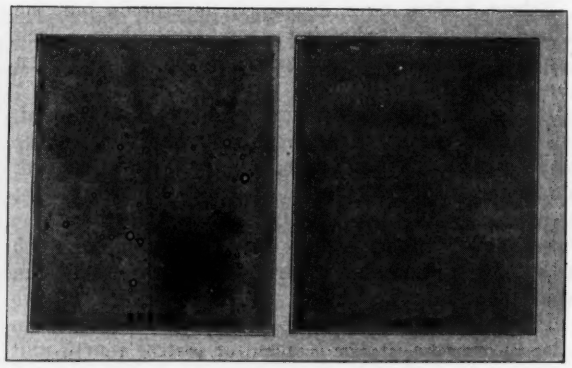


FIG. 3. MICRO-PHOTOGRAPHS SHOW THE CONDITION OF THE OIL BEFORE AND AFTER RECONDITIONING

turbine can be allowed to flow to the emergency tanks. While this does not completely change the oil in a turbine, the admixture can be continued until the condition of the oil in the turbine system very closely approaches that of fresh oil.

It is customary at the Acme Plant to sample the oil in each turbine weekly. These samples are sent to the laboratory and tested for acid, in terms of the neutralizing agent used in the test, that is milligrams of KOH needed to neutralize the acid in one gram of oil, water and sludge.

When the system was first put into operation, a check was made on the purification process by microphotographs. These are taken of slides of oil prepared $\frac{1}{16}$ of an inch thick which have been allowed to settle over night after preparing. It was found impossible to focus the miscroscope on the water and sludge in the slide if it was not properly settled. A magnification of 125 diameters was used and Fig. 3 shows the turbine oil before and after the washing, settling and centrifuge process.

Oil Is Reconditioned When Acid Content Approaches 1 mg. of KOH

It is customary at the above mentioned plant to process the oil if excessive water or sludge is reported, or if the acid test approaches 1 mg. of KOH. The acid

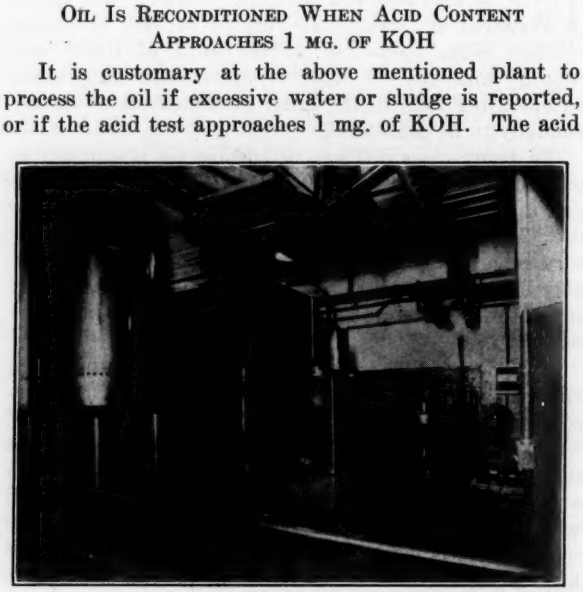


FIG. 4. EMERGENCY STORAGE TANKS, SETTLING TANK, CLEAN OIL STORAGE, CENTRIFUGE AND PUMPS AS INSTALLED IN THE ACME PLANT

content as reduced by the process varies considerably, no doubt due to slightly varying temperature conditions, a representative figure being about 0.2 mg. of KOH.

So far the problem has not been pressing enough to warrant the expense of extended tests to determine the most efficient procedure as regards temperature of oil and water in the washing process, length of time and temperature during the settling period and temperature of the oil when passing through the centrifuge. The theory as brought out in the Prime Movers Committee Reports of the N. E. L. A. in former years is that the oxidation of the oil increases its acidity. Then if water gets into the oil while it is still in the turbine, the water combines with the acid and forms sludge which will precipitate any place in the system. If, however, the system is tight the acid will increase to 2 or 3 mg. of KOH without showing any great amount of sludge.

This water washing process forestalls the possibility of a water leak starting into the turbine oil and throwing down a lot of sludge in the cooler and piping. It puts the oil in intimate association with the water and the reaction, which forms the sludge, is further encouraged by bringing up the temperature in the settling tank. It is also quite possible that the sludge absorbs some of the water, thus helping the centrifuge to get a more perfect separation.

Steam Engine Shows High Efficiency

RECENTLY a single cylinder back pressure Hartman-Kerchove engine with piston valves was tested in a German wool and linen weaving plant and the results reported by Waermewirtschaft. Increased steam pressure, steam temperature, rotating and piston speeds made possible by improved design and construction, enable this engine to meet modern industrial requirements of feed heating and exhaust steam utilization more simply than engines with pressure control systems. No involved types of pressure regulators with servomotors are required for the Kerchove engine as its free latch, or drop valve, cutoff and its low back pressure regulator makes this unnecessary, especially so in compound steam engines with stage bleeding. Advantages of the Kerchove type engine—piston valves, three-section steam cylinder, and heated cylinder heads—have been increasingly recognized.

Steam consumption tests are noteworthy because they were obtained during practical, continuous operation in a textile plant and because it was the first engine without positive controlled cutoff control operating continuously at the high speed of 304 r.p.m. In spite of small power, the results were favorable from the mechanical and thermal viewpoints. The engine 10.84 in. by 15.7 in. with a 2.14-in. piston rod used a total of 10,053 lb. of 89 lb. gage 447 deg. F. steam during the test of 363 min. Back pressure was kept constant at 3.82 lb. per sq. in. gage. An average load of 80.86 b.hp. was carried, giving from the average of 88.99 i.hp. a mechanical efficiency of 91.66 per cent. From the Mollier diagram the adiabatic heat drop is 144 B.t.u. per lb. of steam, about 70 per cent of which is in the superheated region. Quality at exhaust about 98 per cent. Under these conditions the Rankine cycle ratio of the engine is 85.5 per cent.

In connection with the mechanical efficiency of 91.66 per cent it is noted that the engine was built to develop 139 i.hp. with a steam pressure of 176 lb. so that the flywheel and gearing is too heavy for present conditions. A higher pressure boiler is to be installed and is expected materially to increase this factor. Indicator cards, Fig. 2, show that similar cards are obtained with both high and low speed engines and that the throttling effect of the steam line is very moderate.

By using forced lubrication and the latest improvements in bearings and friction-producing parts, mechanical efficiencies of 95 per cent and more are expected with modern single cylinder steam engines. Thermodynamic, not mechanical, efficiencies of steam engines compare favorably with those of the steam turbine. The piston valve engine appears to be, in its field, as economical and as safe as the steam turbine, and as oil separators are efficient enough to make the exhaust steam practicable for textile and dye works their application will undoubtedly increase.

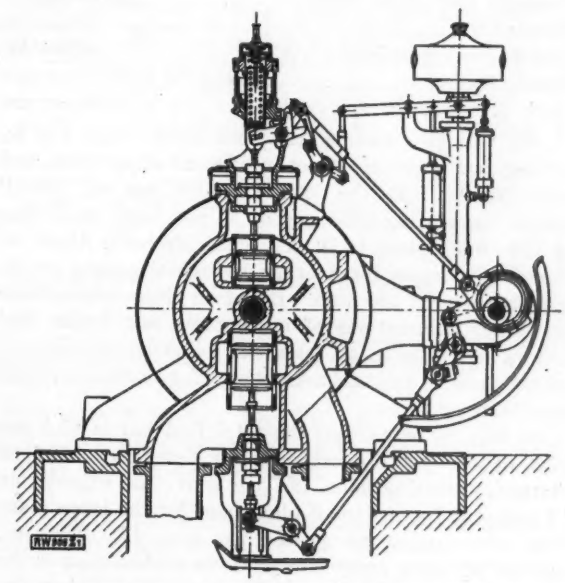


FIG. 1. CROSS SECTION OF THE HARTMAN-KERCHOVE ENGINE USED IN THE TESTS REPORTED

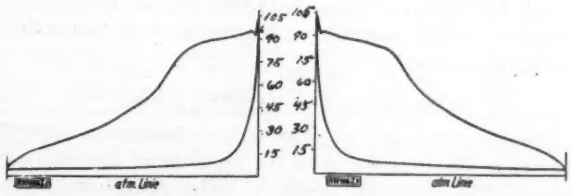


FIG. 2. INDICATOR CARDS TAKEN DURING THE TESTS COMPARE FAVORABLY WITH THOSE FROM SLOWER SPEED ENGINES

THE CITY OF LOS ANGELES, Calif., Light & Power Bureau, has secured a court decision permitting the construction of its proposed municipal steam-operated electric generating plant at San Pedro Harbor, expected to cost in excess of $1,500,000 with equipment.

Operating Costs of Industrial Plants

Cost Comparisons and Methods of Reducing Power Plant Costs, Taken from a Paper on The Industrial Boiler Plant, Presented Before Detroit Section, A. S. M. E., March 30, 1927. By Chas. S. Gladden*

LET US COMPARE the cost of operating a small plant, say, one having three 300-hp. boilers in operation with a fourth unit as a spare, stoker fired, with a relatively large plant having the same number of units but each unit four times as large. We will assume that a good grade of coal costing $4.00 f.o.b. the plant is used which contains 8 per cent ash and 13,500 B.t.u. as fired. We will further assume boiler room labor wages as follows:

Foremen and repair men	$0.80 per hr.
Firemen	.70 per hr.
Coal and ash handlers	.50 per hr.
Superintendent	$250.00 to $350.00 per mo.
Clerk	$150.00 per mo.

We will also assume that both these plants are receiving just ordinary, if not indifferent supervision, and consequently that the smaller plant has an overall monthly operating efficiency of 65 per cent, while that of the larger plant is 70 per cent. Probably these assumed efficiencies for average industrial plants are at least 5 per cent too high. Based on these assumptions and other assumptions of maximum steam loads, load factors and installation costs, the following estimates of operating costs and of fixed charges for these two plants have been prepared.

It will be noted that the total fuel bill is 65.1 per cent of the total operating cost, exclusive of fixed charges; operating labor 19.7 per cent; and supervision 4.1 per cent for the small plant, and for the large plant these percentages become 67.8 per cent, 17.9 per cent, and 2.3 per cent, respectively. It is evident that if the operation of the plant can be improved so that the boiler efficiency in each case may be raised, say, 3 per cent, the reduction in the fuel bill for the small plant would be $2133 per year while that for the large plant would be $7385 annually. Figure 1 shows estimated comparative costs.

How to Reduce Existing Losses

Now, how would it be possible to bring this about? Obviously, the answer is to reduce some of the existing losses. The principal losses in boiler operation which may be more or less controlled are:

1. The waste of heat in the flue gases due to
   (a) Too much excess air, causing low CO_2
   (b) Accumulation of soot on the boiler tubes, or to poor condition of baffles, causing high flue gas temperatures.
2. The waste of fuel in the form of unburned carbon in the ash refuse.

The extent that these losses are greater than those established under best practice or test conditions may be termed "preventage losses" and the best firemen are the men who can reduce the preventage losses to a minimum or eliminate them.

In the ordinary small plant, one would find (if instruments were available) that the CO_2 of the flue gas would run about 8 to 10 per cent. To secure an improvement in boiler efficiency of 3 per cent would only mean raising this percentage of CO_2 from 8 per cent to 9.5 per cent or from 10 per cent to 12.3 per cent, which is not at all impossible; or, disregarding the waste of heat in the flue gas if the ash contained 40 per cent of carbon, a reduction to 21 per cent would mean an increased boiler efficiency of 3 per cent.

Again, in the large plant, if ordinary practice exists, one would probably find the CO_2 meters (if there were any) out of commission from neglect; but if they were put in commission and checked for accuracy, one would likely find that the CO_2 would not run over 10 per cent. If this were increased to 12.3 per cent through diligent supervision of the firemen, a 3 per cent increase in boiler efficiency would result. It is likely that the soot is blown but once a day, or at most once a shift, or the baffles need tightening up; if this is the case, it is an easy matter to pick up another one or two per cent in boiler efficiency by careful supervision. With a high percentage of unburned carbon in the ash, resulting from careless cleaning of fires, more watchful supervision may result in gathering in another one or two or even three per cent in efficiency which would otherwise be lost in the ash pile.

Combustion Control Equipment Necessary

Use of combustion control equipment is of greater importance for promoting efficiency in the industrial boiler plant than is generally supposed. No fireman attending several boilers can perform the service of continually maintaining proper draft conditions that can be accomplished by automatic equipment. This equipment, however, must be maintained in a perfect, tuned-up condition to obtain best results; but once the boiler operator understands the value of this control system he will take pride in keeping it in its best operating condition. It is a safe assertion that in the average industrial plant there are possibilities of saving from 3 to 10 per cent of the fuel that is now lost through inefficient operating labor, or supervision, or both. It is evident that the management could well afford to pay a liberal bonus for diligence on the part of the plant superintendent or foreman who could produce such savings. Another method that might be productive of results in reducing preventable losses would be the awarding of a bonus to the firemen or crew who maintain a low total of preventable losses during the payroll period, increasing the bonus as the total of the preventable losses approaches complete elimination.

In order to determine the extent of the preventable losses it is necessary to install complete boiler plant instruments, including CO_2 recorders, flue gas temperature recorders, steam flow meters of the indicating and integrating type and draft gages. A thorough checking each day of these records should be made by the superintendent or by a clerk to determine the daily averages

*Director, Power and Maintenance Section, General Motors Corp., Detroit, Mich.

ESTIMATED OPERATING COSTS AND FIXED CHARGES

Plant of 4 - 1200 H.P. Boiler Units, Stoker Fired.
Investment @ $125,000 per H.P. = $600,000.
Fixed Charges -Depreciation 8%, Insurance & Taxes 2%, Interest 5%-15%.
Coal 13,500 B.T.U. as fired, $4.00 per ton, F.O.B. Plant
Average over all efficiency 70%.

	7 HEATING MONTHS			5 NON-HEATING MONTHS			TOTAL FOR YEAR		
Total Coal Burned	33,100 Tons			11,825 Tons			44,925 Tons		
Total Water Evaporated	613,000 M.lb.			219,000 M.lb.			832,000 M.lb.		
Maximum Load	200 M.lb.per Hr.			100 M.lb.per Hr.			200 M.lb.per Hr.		
Load Factor	60%			30%			52%		
	COST	COST per M.lb.	Per Cent	COST	COST per M.lb.	Per Cent	TOTAL COST	TOTAL COST per M.lb.	Per Cent
Fuel	$132,400	.2160	72.4	$47,300	.2160	57.70	$179,700	.2160	67.80
Operating Labor	27,600	.0450	15.1	19,700	.0900	24.00	47,300	.0570	17.87
Maintenance	17,000	.0276	9.3	11,650	.0532	14.20	28,650	.0345	10.83
Supplies	2,400	.0039	1.3	850	.0039	1.05	3,250	.0039	1.23
Supervision	3,500	.0064	1.9	2,500	.0114	3.05	6,000	.0072	2.27
			100.0			100.0			100.0
Total	$182,900	$.2989	77.7	$82,000	$.3745	68.60	$264,900	$.318	74.7
Fixed Charges	52,500	.0857	22.3	37,500	.1710	31.40	90,000	.109	25.3
TOTAL	$235,400	$.3846	100.0	$119,500	$.5455	100.0	$354,900	$.427	100.0

Plant of 4 - 300 H.P. Boiler Units, Stoker Fired.
Investment @ $150.00 per H.P. = $180,000.
Fixed Charges; - Depreciation 8%, Insurance & Taxes 2%, Interest 5% = 15%
Coal,13,500 B.T.U. as fired, 8% Ash, $4.00 per ton F.O.B. Plant.
Average over all efficiency, 65%.

	7 HEATING MONTHS			5 NON-HEATING MONTHS			TOTAL FOR YEAR.		
Total Coal Burned	8,920 Tons			3,180 Tons			12,100 Tons		
Total Water Evapo.	153,250 M.lb.			54,750 M.lb.			208,000 M.lb.		
Maximum Load	50 M.lb.per Hr.			25 M.lb.per Hr.			50 M.lb.per Hr.		
Load Factor	60 per cent			30 per cent			52 per cent		
	COST	COST per M.lb.	PER CENT	COST	COST per M.lb.	PER CENT	TOTAL COST	TOTAL COST per M.lb.	PER CENT
Fuel	$35,650.	$ .2325	70.2	$12,700	$ .2325	54.3	$48,350	$ .2325	65.1
Operating Labor	8,500	.0554	16.7	6,100	.1115	26.1	14,600	.0702	19.7
Maintenance	4,300	.0280	8.4	3,100	.0547	13.3	7,400	.0356	9.9
Supplies	650	.0042	1.3	230	.0042	1.0	880	.0042	1.2
Supervision	1,750	.0114	3.4	1,250	.0228	5.3	3,000	.0145	4.1
			100.0			100.0			100.0
Total	$50,850	$ .3315	76.4	$23,380	$ .4257	67.5	$74,230	$.3570	73.4
Fixed Charges	15,750	.1030	23.6	11,250	.2055	32.5	27,000	.1300	26.6
TOTAL	$66,600	$ .4345	100.0	34,630	.6312	100.0	$101,230	.4870	100.0

FIG. 1. SHOWING ESTIMATED COMPARATIVE COST FIGURES AND FIXED CHARGES FOR A SMALL AND A LARGE BOILER PLANT

and determine the total preventable losses by comparison with standards set up for the plant.

It is suggested that a complete and thorough accounting system be established by co-operation with the accounting department, whereby the actual cost of producing steam month by month may be definitely known.

This should be segregated into the essential component parts of the total cost. An example of such a monthly cost sheet is here shown which is in use at several of the larger plans of the General Motors Corp. For smaller plants the accounts may be grouped together into a more simple form, yet one which is sufficiently segregated to facilitate comparisons of similar component parts of the costs. Figure 2 shows how operating costs may be compiled for analysis.

MONTHLY ANALYSIS OF BOILER PLANT OPERATING COSTS

DIVISION_____ FOR MONTH ENDING_____ DAY OF WEEK _____ DATE _____ 192__

	TOTAL CHARGES	COST PER TON OF COAL FIRED	COST PER M. LBS. STEAM DELIVERED
(1) Coal tons f. o. b. plant			
(2) Coal handling			
(a) Fuel and supplies			
(b) Labor			
(c) Repair material and labor			
(d) Electric power			
Total coal handling			
(3) Ash handling			
(a) Labor			
(b) Repair material and labor			
(c) Water for wetting ashes			
Total ash handling			
(4) Boiler room labor			
(a) Firing boilers			
(b) Cleaning boilers			
(c) Water purification			
(d) Boiler plant auxiliaries			
Total boiler room labor			
(5) Repairs—Labor			
(a) Power plant building and stacks			
(b) Boilers, settings, breechings and ash hoppers			
(c) Stokers and stoker drives			
(d) Boiler plant auxiliaries			
(e) Boiler plant piping			
Total labor for repairs			
(6) Repairs—Material			
(a) Boiler plant building and stacks			
(b) Boilers, settings, breeching and ash hoppers			
(c) Stokers and stoker drives			
(d) Boiler plant auxiliaries			
(e) Boiler plant piping			
Total material for repairs			
Total repairs labor and material			
(7) Boiler room supplies			
(a) Oil, waste, miscellaneous tools and supplies			
(b) Chemicals for water purification			
Total boiler room supplies			
Totals carried forward			

	TOTAL CHARGES	COST PER TON OF COAL FIRED	COST PER M. LBS. STEAM DELIVERED
Totals brought forward			
(8) Power plant superintendence			
(a) Salaries of chief engineer and assistants			
(b) Miscellaneous power plant office supplies			
Total superintendence			
(9) Electricity for auxiliaries and lighting			
(10) Water for boiler plant uses			
Total operating cost of boiler plant			
(11) Fixed charges for boiler plant			
Total cost including fixed charges			

BOILER PLANT OPERATING DATA	
(a) Total coal delivered to stokers	M. Lbs.
(b) Total water evaporated by boiler plant	M. Lbs.
(c) Total steam used by boiler plant auxiliaries	M. Lbs.
(d) Total high pressure steam delivered by boiler plant	M. Lbs.
(e) Total low pressure steam delivered by boiler plant	M. Lbs.
(f) Total equivalent useful steam (H.P.+⅓L.P.)	M. Lbs.
(g) Average evaporation per lb. of coal as fired	Lbs.
(h) Average per cent moisture in coal	%
(i) Average B. T. U. per lb. of dry coal	B. T. U.
(j) Factor of evaporation (feed water temperature °F, steam pressure lbs.)	
(k) Equivalent evaporation from and at 212° per lb. dry coal	Lbs.
(l) Average boiler efficiency	%
(m) Total boiler horse power hours generated	B. H. P.-Hrs.
(n) Total rated boiler horse power hours in service	B. H. P.-Hrs.
(o) Average per cent of rated capacity developed	%
(p) Average per cent CO_2 in flue gases	%
(q) Total ash refuse (dry weight estimated)	M. Lbs.
(r) Average per cent ash refuse to coal burned	%
(s) Average per cent carbon in ash	%
(t) Average flue gas temperature	°F
(u) Preventable losses—	
Due to excess carbon in ash	$
Due to excess air (deficient CO_2)	
Due to excess temp. of flue gas	
Total preventable loss	$

FIG. 2. SHOWING HOW OPERATING COSTS MAY BE COMPILED FOR ANALYSIS

Power cost keeping is a subject worthy of considerable thought and, if properly and accurately maintained, is well worth the cost and effort of securing the data. The best results in industrial boiler plant operation will be obtained when competent trained men are employed to operate a plant that is equipped with the most efficient and best selected fuel burning and steam generating equipment; and when boiler plant instruments and cost records, as well as records of performance, are available for constructive study and comparisons.

IN FURNACE wall lining practice, a new departure is the guarantee of the S. Obermayer Co. that any furnace lining of Ramtite, installed during 1927 by that company or according to the practice which it recommends will not spall nor crack within one year of the date of installation. This guarantee is backed by the agreement to furnish enough material to replace any that fails and good faith is insured by a $25,000 bond placed with the Metropolitan Casualty Ins. Co. of New York City. The Ramtite is guaranteed to be made entirely of virgin refractories without any waste material.

Coal Supply

PREVAILING apathy on the part of both domestic and industrial users of fuel toward the existing coal strike is perhaps the one outstanding feature of the present struggle. Not only does the strike fail as newspaper reading but there is lack of editorial comment in business papers, perhaps largely due to the statements of several weeks ago that stocks on hand are large and that the non-union producers are well qualified to supply all reasonable demands.

Little is to be gained by underestimating the importance of the present strike. Coal strikes of the past have lasted several months, and there is abundant indication that the present struggle will stretch into a longer period, probably five or six months. Scarcity will be felt only when existing stocks are out of the way and production is curtailed in non-union fields. If, therefore, the coal user, through misunderstanding or belittlement of its importance, digs heavily into existing stock piles, or relies upon particular mines on temporary arrangement which may be withdrawn at any time, he weakens his own defenses.

It should be clear to all that the strike is of major importance, that existing stocks should be conserved, and that, if this constantly recurring evil is to be done away with, mines actively operating should be supported.

THE ABILITY to write a good report and to express oneself clearly in speech are two valuable assets.

New Plant Helps Reduce Railroad Costs

SIMPLE, RUGGED COAL AND ASH HANDLING SYSTEM INSTALLED WITH NEW BOILER PLANT FOR RAILROAD SHOPS

ILLUSTRATING the policy of railroads to bring about further economy in operating costs, the Michigan Central Railroad recently placed in operation a new boiler plant at its shops in West Detroit. Construction and design were handled by Battey & Kipp, Inc., under the direction of J. F. Deimling, chief engineer of the railroad. The space available for the new building was restricted and a chimney serving the old boilers occupied the position of one of the new stoker foundations. A new chimney was built, the building erected, boilers and stokers installed complete and the old chimney taken down without disrupting the continued operation of the old boilers.

Four 350-hp. Wickes cross drum water tube boilers equipped with Copes feed water regulators, Diamond soot blowers, Hagan damper control, steam purifiers and deconcentrators, are set over Detroit V type stokers in two batteries of two boilers each in a boiler room measuring 48 by 62 ft. The arrangement of units, the architectural treatment of the building and the 185-ft. radial-brick chimney are such that future units may be added by extending the building.

The capacity of the Beaumont coal handling system is 30 t. per hr., or sufficient to store fuel for 24 hr. operation in 3 hr. Coal is delivered in standard bottom center or bottom side dump gondolas to a reinforced concrete track hopper 18 ft. square, to be fed by means of a 30-in. apron feeder to a 30 by 30 double roll crusher. The apron and crusher are driven by a 25-hp. motor controlled from the boiler room floor level with a safety cut-out switch. Crushed coal is loaded by an automatic loader to a 40-cu. ft. skip hoist bucket which in turn discharges through a hopper and chute into a 40-cu. ft.

FIG. 1. BOILER ROOM LIGHTING IS WELL TAKEN CARE OF BY LARGE SASH AREAS AND ARTIFICIAL LIGHTS

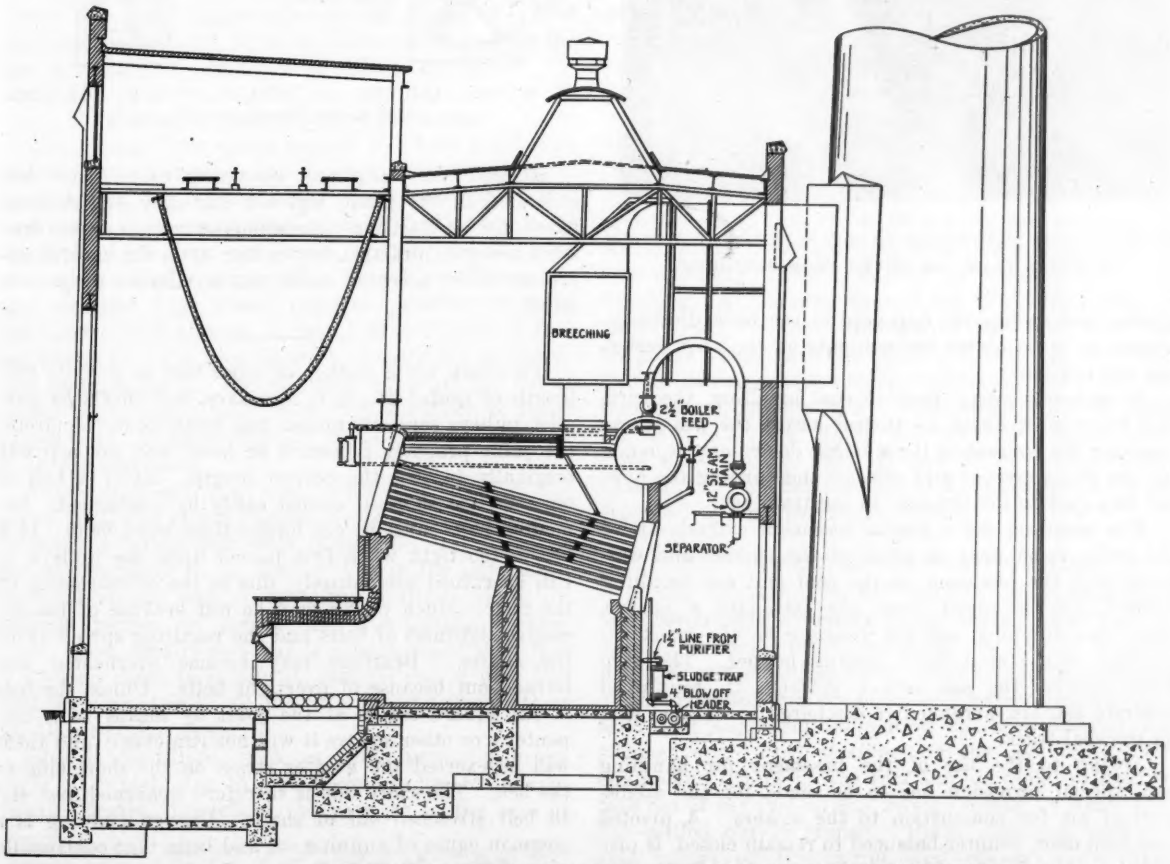


FIG. 2. A CROSS SECTION OF THE BOILER ROOM SHOWS THE COMPACT ARRANGEMENT

tram car. Skip hoist and tram car are operated in synchronism by means of cables passing over individual winding drums mounted on a common shaft and driven by one 20-hp. motor. The tram car discharges uniformly into a 150-t. suspended concrete lined bunker, and coal is distributed later to the stoker hoppers by a hand-operated 1000 lb. weigh larry.

Electrical and mechanical interlocks and safety devices insure proper operation of the system and guard against accident to the machinery or operator. The electrical devices consist chiefly of over-travel, slack cable, and safety cut-out switches.

A turn stile or switch stand near the ash tracks acts as a mechanical and electrical safeguard in an ingenious fashion, to prevent putting coal in ash bunker or ash in the coal bunker. An extended operating arm of the turn stile projects across the tracks on which the ash car is operated while coal is being crushed and conveyed. In order to dump ashes into the skip hoist, the operator must first swing the lever arm to a position parallel to the ash track. This movement automatically cuts off the electric current to the apron feeder and coal

FIG. 3. COAL IS DISTRIBUTED TO THE BUNKERS BY A CABLE OPERATED TRAM CAR DRIVEN FROM SKIP HOIST

crusher and swings the flap gate in the hoist discharge hopper so as to divert the contents of the skip bucket into the ash bin.

In order to swing back to coal handling, the turn stile lever must again be turned across the ash track, releasing the current to the starting device of the motor for the coal conveyor and crusher and turning the hopper flap gate to deliver coal to the tram car.

For handling ash a partial basement extends under the boiler room floor in front of the stokers and connects with the basement in the coal and ash handling tower. Ash is raked from the pits into a narrow gage, end dumping, ash car running on the track extending to the skip hoist loading hopper. The skip hoist delivers the ash into a 2000-cu. ft. reinforced concrete ash bin, arranged to discharge to railroad cars on the coal track.

Owing to the use of the basement for handling ash, special provision has to be made for the admission of air for combustion to the stokers. A pivoted cast-iron door, counter-balanced to remain closed, is provided in the front ash pit wall in each boiler. This door is operated by a notched lever extending through the boiler room floor and engaging a cross bar in a sectional floor grading, thus providing for a graduated admission of air.

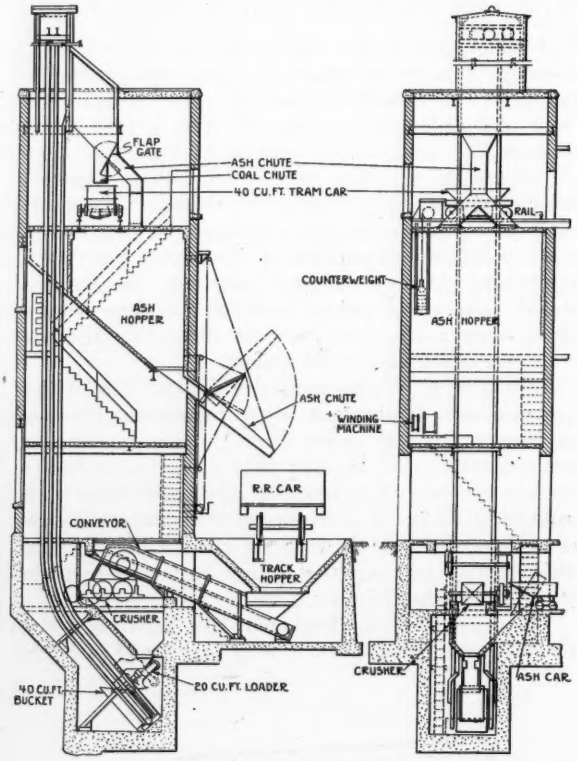


FIG. 4. COAL AND ASH ARE BOTH HANDLED BY THE SAME SKIP HOIST WITH SUITABLE INTERLOCK

Rugged simplicity and operating convenience are embodied in the plant, and the efficiency expectations based, not on startling innovations or radical departures from accepted practice, but rather upon the careful coordination of accepted units and auxiliaries of proven merit.

IN ORDER for a leather or other belt to give its full length of useful life, it is necessary that shafts be parallel, pulleys correctly alined, belt joints be cut squarely, the joint properly cemented or laced and the belt cut originally to just the correct length. After a belt is once cut too short, it cannot easily be lengthened. Cemented belts must be cut longer than laced belts. If a belt is too tight when first placed upon the pulleys, it will be ruined prematurely, due to the overstressing of the fiber. Much power may be lost because of the excessive tightness of belts and the resulting springing of the shafts. Bearings may become overheated and burned out because of overtight belts. Unless the belt is cut square across at the joint by means of a carpenter's or other square it will not run evenly and there will be exerted the greater stress on the short side of the belt. The short side is therefore weakened first and th belt stretched out of shape. Uneven running is a common cause of running off and belts that continually run off are very short lived.

Oil Pipe Line Power and Fuel Problems

Oil, Steam and Electricity as Motive Power Agents. Comparative Installation and Maintenance Costs. By S. P. Young*

POWER FOR moving crude oil through a main pipe line system is obtained from a chain of pumping stations spaced about 40 mi. apart along the line. The installations, which are of a permanent nature, usually consist of a number of Diesel engines direct-connected to duplex or triplex reciprocating pumps operating at between 600 to 800 lb. pressure. The oil is thus relayed from station to station until it reaches its destination.

Two Classes of Pumping Stations

Besides the main line pumping stations there are numerous gathering pump stations in the oil fields. The problem of motive power differs in the latter class of plant from that of the main line plant. The gathering stations take the oil produced in the field and pump it into the main trunk line system. They are of temporary nature and frequently it is necessary to construct them in the shortest possible time.

Gathering stations ordinarily have used Diesel or semi-Diesel engines to drive reciprocating pumps. Electric motors are now coming into use for this purpose. Another recent development is the use of motor-driven centrifugal pumps placed in the main line midway between existing pump stations. Such installation promises to increase the capacity of an existing pipe line at less cost than it would take to loop the line, in cases where temporary additional capacity is needed. It is not believed, however, to be as economical as looping the line if permanent additional capacity is desired.

Fuel Economy Determines Use

The change from steam engines to Diesel engines as motive power for main line pump stations was due to the low fuel cost of the latter which consume at full load under ideal conditions 0.45 lb. of fuel or crude oil of about 18,500 B.t.u. per lb. per br.hp-hr. for the sizes of engines usually employed. Actual monthly averages obtained from Diesel engines operating in main line service show a range of from 0.44 to 0.55 lb. of fuel per br.-hp-hr. The high figure is usually due to operation on light loads. The efficiency curve of the Diesel engine is practically level from full load down to about 75 per cent. It then drops off considerably as the load is further decreased.

Diesel engines are so much more economical in the use of fuel than steam engines served by either coal or oil-burning boilers that even though the initial cost is somewhat greater in the former than in the latter case, the total annual cost of operating a Diesel plant, including interest on investment, depreciation, obsolescence, labor, repairs and fuel is enough lower than that of a steam plant to justify its general use in pipe line work and practically all recent pipe line installations use Diesel engine power.

Special conditions, such as when pumping heavy crude oil, which, due to high viscosity, has to be continually heated throughout the year, as in the case of some California and Mexican crudes, warrant the use of steam equipment as the exhaust steam is available for heating the oil to reduce its viscosity, thereby making it more fluid and less difficult to pump. If Diesel power were installed it would also be necessary to install an auxiliary steam heating plant to heat the oil. This would result in higher total annual costs than is the case with a steam plant. The question might be asked why not install steam instead of Diesel engine pumping equipment on main trunk lines pumping high gravity crude oil of high viscosity. Some of these oils congeal at about 50 deg. F. and such high pressures are sometimes encountered in pumping these oils that it is necessary to heat the oil.

Pipe lines, however, have installed and are now installing Diesel pumping equipment in their main trunk line stations coming from high viscosity fields. The reason is that it is necessary to heat the oil only during a few winter months and possibly not even then, as by experience it has been found that by moving the oil by turbulent flow and keeping it moving continuously, heating is not always necessary and, although the full capacity of the line would not be maintained by pumping the oil cold, it is more economical to lose the pipe line tariff on the decreased amount of crude pumped than to pay the extra fuel expense of heating to get full pumping capacity.

Fuel Oil Versus Crude Oil

As to fuel supply for Diesel engines in main line stations the question of whether to use crude oil taken directly from the pipe line system or fuel oil shipped from the nearest refinery is an economic one, depending upon the market conditions of these oils. For instance, around Jan. 1, 1927, 22 to 26 gravity fuel oil could be laid down at a certain main line pumping station for approximately $1.73 a barrel, including freight and handling. At the same time, if the 37 gravity crude oil taken from the pipe line system had been used the crude oil would have cost $2.37 a barrel. It is evident that in this case it was more economical to use fuel oil, the consumption per br.hp. being practically the same for both oils. On March 15, 1927 the relative costs were $1.65 for the fuel oil and $1.30 for the crude. Consequently at that time it was more economical to use crude oil at that particular station.

Desirable and Undesirable Properties

Crude oil taken from mid-continent pipe line systems has proven satisfactory for Diesel engines after the fine sand, grit and "black sediment," which is a heavy liquid mass that settles out of crude oil and is composed of an emulsified mixture of oil and water, together with sand, grit and other impurities, has been drained and strained out. Fuel strainers on the fuel line to the engine and drains on the fuel storage tank are used to take out of the fuel oil any foreign matter or water that has settled out in transit. Black sediment clogs the fuel valves of the engine and causes many other

*Sinclair Pipe Line Co. Paper read at meeting of Mid-Continent section of the A. S. M. E. at Tulsa Okla., April 7.

troubles, while grit causes rapid cylinder wear and leaky fuel and fuel pump valves.

In considering the problem of the proper fuel to use in a Diesel engine, regardless of whether it be crude or fuel oil, as a general rule, no heavier oils should be used than those which can be burned with a smokeless exhaust. A smoky exhaust means improper fuel combustion and results in leaky and possibly sticky exhaust valves. It also increases fuel consumption.

Corrosive Action of Sulphur

Another impurity in the fuel which causes trouble is sulphur. This often forms sulphuric acid, which corrodes the exhaust valves and piping. Some engineers say this corrosive action takes place after the engine is shut down as the sulphur gases in the exhaust form sulphuric acid with the condensed moisture from the exhaust after the engine has cooled off. They further assert that the remedy is to change over from the regular high sulphur content fuel to a special low sulphur grade of fuel.

In actual pipe line practice it has been found that corrosive action exists not only when the engine is shut down but also when it is running on a fuel with a relatively high sulphur content. Corrosive action can be greatly retarded by using stainless steel fuel pump valves with tobin bronze seats. Fuel pump plungers of a rust-resisting material and cast-iron fuel needles are also used to resist corrosion.

Residue content may be formed when oil has been heated in a closed oven for 120 hr. at 575 deg. F. A high residue content in oil is undesirable because of resulting high cylinder wear.

Ash content is the most detrimental remnant of the combustion of fuel oil in Diesel engines. It is usually composed of mineral matters such as quartz and silicates or oxides of iron and aluminum, which, mixing with the film of lubricating oil, adhere to the cylinder walls and accumulate and cause excessive wear of exhaust valves as well as of cylinders.

Comparative Costs of Diesel and Electric Power for Oil Pumping Stations

COMPARATIVE COSTS OF DIESEL AND ELECTRIC POWER
Actual Installation Cost of 475-h.p. Diesel Station (Consisting of Three 75-h.p. and One 250-h.p. Unit and Suction Pumps)
(This does not include manifolds and fields lines, stock tanks, warehouse cottages, cost of station site, etc.)

Pump station buildings		$ 13,965.70
Machinery	$ 59,099.36	
Machinery foundations	9,160.62	
Machinery installations	6,110.00	
Total machinery (includes all auxiliary equipment inside station building)		$ 74,369.98
Auxiliary equipment, outside (station building, water tank, reservoir and water lines, fuel lines and tank, lub oil lines)		$ 7,547.42
Total cost		$ 95,883.11

Same for 495-h.p. Electrically-Driven Station of Six 75-h.p. Motor-Driven Units and Three 15-h.p. Motor-Driven Suction Pump Units

Pump station buildings		$ 9,563.00
Machinery	$ 22,623.60	
Machinery foundations	2,611.03	
Machinery installations	2,220.52	
Total machinery	$ 28,455.15	
Total cost		$ 38,018.15

COMPARATIVE ANNUAL COST OF OPERATION
Pumping 24,000 bbls. of crude oil per 24 hours at 600 pounds pressure, average total load, 280 brake horsepower. One 75-h.p. unit held as a spare.

For 475-h.p. Diesel Station

Interest and depreciation at 15 per cent	$ 14,382.47
Machinery maintenance, at $4 per installed horsepower	1,900.00
Labor (same station crew as at electric station so will not affect result).	
Cost of fuel—	
(a) When fuel is crude at $2.37 per barrel	$ 10,071.23
(b) When fuel is crude at $1.30 per barrel	5,525.00
(c) Average	$ 7,798.13
Total annual charges (less labor)—	
(a) For fuel at $2.37 per barrel	$ 26,363.70
(b) For fuel at $1.30 per barrel	21,817.47
(c) Average total annual charges	$ 24,090.59

Same for 495-h.p. Electric Station

Interest and depreciation at 15 per cent	$ 5,702.73
Machinery maintenance, at $1 per installed horsepower	495.00
Labor (same as for Diesel station).	
Cost of electric power (averages close to 1.4 cent a kilowatt hour)	$ 34,743.00
Total annual charges (less labor)	$ 40,946.73
Difference in annual operating costs in favor of Diesel station	$ 16,856.14

TO RECAPITULATE

Investment in Diesel station	$ 95,883.11
Investment in electric station	$38,018.15
Difference in favor of electric station	$ 57,864.96

Specifications for Diesel Engine Fuel Oil

Characteristics of a desirable fuel for Diesel engines are given in the following specifications:

The fuel oil shall be free from acid, grit, fibrous material or any foreign material which is liable to damage the engine mechanism or clog the fuel valves.

Gravity of the fuel oil shall be from 22 to 30 deg. A. P. I. at 60 deg. F.

Flashpoint may range from 125 to 250 deg. F. (Pensky-Martin closed tester).

Burning point may range from 160 to 300 deg. F.

Heating value shall be 18,500 B.t.u. or better per lb. of fuel oil.

Sulphur content shall not exceed 1 per cent.

Water content shall not exceed 0.3 of 1 per cent.

Ash content shall not exceed 0.1 of 1 per cent.

Residue after heating in a closed oven for 120 hr. at 575 deg. F. shall not be over 10 per cent.

Viscosity shall not be greater than 3000 Saybolt seconds at 40 deg. F.

The volume of fuel oil shall be determined on the basis of 42 gal. per bbl., 231 cu. in. per gal. at 60 deg. F. For a volume correction at different temperatures the National Standard Petroleum Oil Tables shall be used.

Rapid extension of electric transmission lines in the oil fields and gradual decrease in electric power rates have forced the issue of electric power on the oil industry. Whether or not to install electric power in place of Diesel engines is another economic question that must be decided for each individual case. At the present stage of electric power development it appears that for permanent installations at main trunk line pumping stations the Diesel engine direct-connected to a reciprocating pump is more economical than the electric motor direct-connected or belted to a reciprocating pump because the fuel cost for the Diesel engine installation is less than ¼ of the cost of electric power. This more than offsets the higher fixed charges of the Diesel engine installation.

Due to the lower installation cost of the electric pumping station, however, it is more economical to make use of a motor installation for a temporary gathering station in a flush field than to use the Diesel station. The period of flush production of such a field is usually from 3 mo. to 1 yr. The following figures show that where an oil pumping installation is to be used for less than approximately 3½ yr., it is more economical to install an electric station, provided, of course, current is available at a reasonable rate. It will also be shown that where the installation is to have a life of more than 3½ yr., it is more economical to use the Diesel engine installation.

From the table we have 57,864.96 ÷ 16,856.14 = 3.44 yr. of operation for the Diesel station to catch up and pass economically the electric motor-driven station. Diesel power is, therefore, more economical for main line stations and electric power for temporary gathering stations.

An important advantage of the electric gathering station is that it can be installed and put into operation in less time than the Diesel station, due to the smaller

machinery foundations required, less erecting time needed, absence of auxiliary machinery, water, fuel tanks, lines, etc. The time element is an important commercial advantage in a new field because the first pipe line to start pumping oil gets the first customers and usually, when the field plays out, is found to be the last pipe line to be holding them.

Electric installations have a third advantage in that less investment is left in the ground in the form of concrete foundations, reservoir, etc., after the field production has declined and the station has been dismantled. Another instance in which the advantage is with the electric installation is in an old field of settled production where the amount of oil pumped is small. In many cases of this kind a small electric motor, belt connected to a pump cannot only be installed for less expense than a Diesel pumping unit but can also be operated at less expense since the field gager can operate the electric station, leaving it running while he makes his field runs. On the other hand, he would have to stay with the Diesel plant while it was running and not enough time would be left in a day for him to make field notes, necessitating the employment of an extra man as a pumper.

Continuous Fuel Indicator for Diesels

IT IS EXCEEDINGLY important that each cylinder in a multi-cylinder Diesel engine should receive its correct share of fuel oil. Even with timing equipment, accurate fuel oil pumps for each cylinder, etc., it is impossible to have a direct knowledge or measurement of the fuel fed to each cylinder. When adjustments in fuel supply are made, there is no direct and immediate way to tell the results.

A simple and practical fuel indicator operating continuously and individually for each cylinder will solve the problem. Captain Carlo Baulino of the Italian Royal Naval Engineers has developed a quite efficient fuel indicator which is now in use on the submarine engines of the Italian navy. It is also recommended for engines on land.

Fuel oil from the service tank is delivered to the small main tank A shown in the illustration, where a constant level is maintained by means of a float control valve or an air cock. Small subsidiary tanks C, one for each cylinder, are located next the small main tank. They receive fuel oil from the small main tank A through accurately and evenly sized circular orifices D. Each tank C is connected with a fuel oil pump and cylinder. Any pump gland leakage is piped back to the tank C connected to that pump.

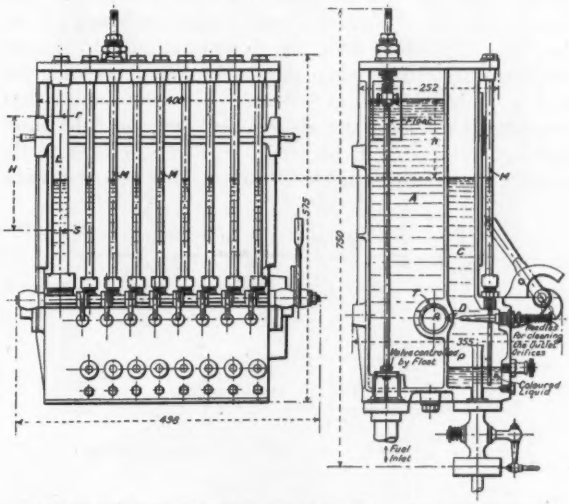
The size of the orifices D is predetermined by the density and viscosity of the fuel oil, and the quantity that must be fed per unit of time. The orifices are of a size to assure a fairly considerable difference in level in the tanks A and C. Floats or other level indicators are placed in both tanks A and C. The difference of level in the two tanks indicates the amount of fuel oil fed to each cylinder on some kind of scale. When the levels in tanks C are of the same height, the flow to each cylinder must be equal.

Since the rate of flow depends not only upon the size of orifice, but upon the viscosity of the oil, the orifices are constructed so that they may be enlarged or decreased simultaneously and correspondingly equally by means of one lever, thus providing the correct difference in level for the scale to suit any grade or viscosity of oil.

The use of floats carrying pointers being bulky and involved, a set of gage glasses with a colored liquid and equipped with a sliding straightedge fitted horizontally behind the row of gage glasses would facilitate the reading and testing.

The Baulino fuel indicator built for a 2000-hp., 8-cylinder submarine engine has a set of orifices adjustable from 4 to 8 mm. diameter. Choking of the orifices by impurities is hardly possible, but as a precaution an easily operated pricking needle is provided for each orifice.

On the 300-hr. continuous test run, the remarkable regularity of the 2000-hp. multi-cylinder engine was obtained and maintained by the adjustment of the fuel

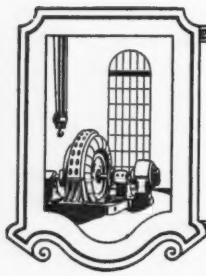


ELEVATION AND SECTION OF BAULINO FUEL INDICATOR

oil pump tappets in such a way as to maintain the oil levels in the small tanks C at a constant and uniform height, thus assuring that every cylinder was equally supplied. There were no obstructions in the calibrated orifices D. The maximum deviation of the 275-hp. cylinders was ¾ hp. The indicator on the gage L of the main tank A and shop tank calculation showed a total fuel oil consumption of 194 and 195 gram per hp-hr. respectively.

The fuel oil indicator may be installed on the control platform or close to the fuel oil pumps. It is unaffected by movement such as on a rough sea.—Abstract from the Engineer, of London.

ERECTION of structural steel by welding has been put to practical use in construction of a new ball room on the roof of the Alcazar Hotel in Cleveland by the National Iron & Wire Co. of that city. Two reasons determined this course; connections to the old structure could be made with minimum disturbance to existing walls; noise was avoided, which was highly desirable in a residence hotel. Comparative costs are not available but expense was not a determining factor.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Principles of Automatic Voltage Regulators

THE AUTOMATIC VOLTAGE REGULATOR IS ONE OF THE MOST INGENIOUS DEVICES IN THE POWER STATION. THIS ARTICLE DISCUSSES ITS DEVELOPMENT AND DESCRIBES SOME OF THE LATEST TYPES. BY J. H. ASHBAUGH*

VOLTAGE REGULATORS have been in use slightly over 25 yr. The first automatic generator voltage regulator was made approximately 1900 by Allen A. Tirrill, and was for a direct current generator. Mr. Tirrill was only 17 yr. old and worked in a sawmill at the time. The story goes that it was his duty to change the rheostat setting when the logs started through the mill, to hold a constant voltage. He soon found that by putting a temporary short circuit on the field rheostat and removing it, he could keep the voltage fairly constant, more so than by merely moving the rheostats.

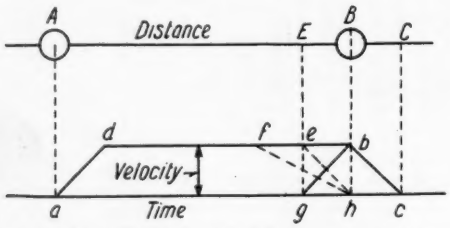


FIG. 1. DISTANCE AND VELOCITY CURVES

The next step was to use a relay to do this work for him. The obstacles which he had to surmount both from an engineering and a financial point of view were great. His great patience combined with his natural ability resulted in the development of regulating equipment which gives a performance far superior to any like equipment.

At the time of the development of the first generating voltage regulator the fundamental principle of regulation was not thoroughly understood. No doubt a few men understood it, but it was not known to the extent it is known today.

The fundamental principle of regulation upon which every regulator, whether it be a voltage regulator or a waterwheel governor, is based, is a reaction assisting the restoring device causing the regulator to reach a point of equilibrium at the time the regulated quantity reaches normal. Stating this fact in another and more simple way, is to compare it to an automobile driver. When one is driving a car and wishes to stop at a certain place, he first shuts off the motor and applies the brake, bringing the car to a gradual stop. Should one drive up to the exact spot and then try to stop, the car will coast over, as one cannot stop instantly.

*Westinghouse Electric & Manufacturing Co.

It is also necessary for a regulator to shut off before normal is reached and start applying the brake. Figure 1 shows this condition graphically. In this case if we have the body A and we desire to move it to the point B, then on the velocity time curve the body A would accelerate at the rate ad. If the accelerating force is removed or the resistance becomes equal to the propelling force, the velocity will remain constant as indicated by the line db. If the retarding forces are applied at the instant the body reaches B, it is obvious that the body cannot stop at B, owing to its momentum. The velocity is reduced continuously along the line at BC and the stop is made at C instead of at B; in other words, it has over-traveled by the distance BC.

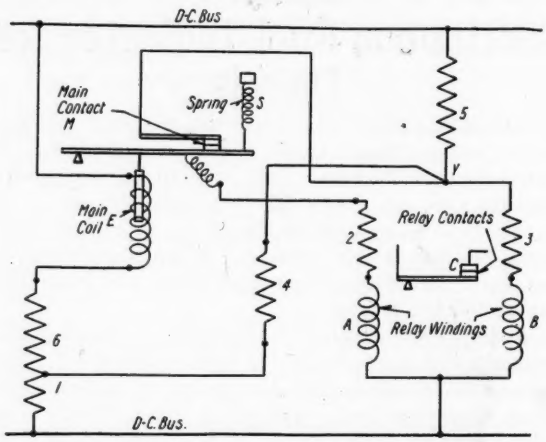


FIG. 2. SCHEMATIC DIAGRAM OF HIGH SPEED REGULATOR

If, when the body has stopped at C, this brings into play the reverse forces which again causes it to accelerate in the opposite direction along the line CB and when the point B is reached, it is again shut off, the body will decelerate along the line BE and will stop at E. Thus the body would overshoot B by the distance BE. If the stoppage at E again brings into play forces which tend to return it to B, the body will be carried back to the point B and then returned again to point C. This results in oscillation called hunting, the body being continually carried back and forth between the points E and C, being impossible ever to stop at B. Assuming, however, that the body at A has started to accelerate along the line AB and reaches a constant speed as shown

by the line de, then when it reaches the point E, the force is applied to cause it to stop, it will coast or decelerate on the line eh arriving at the stop B. In this case, a certain decelerating force has been applied equal to the accelerating force; however, should it be desired to cause the body to decelerate at a slower rate, then it would be necessary to shut off at the point F, allowing the body to decelerate along the line fh.

The amount of anti-hunting necessary to incorporate in any regulator depends upon the type of the velocity curves and also upon whether or not an inoperative zone is placed in the device. It is obvious that if a zone through which the regulator is inoperative is placed in the device so that it would not be operative between the points E and C, it would then not be subject to any hunting action; however, there are few places where such a zone can be added to the regulator so that it is necessary to incorporate added features to prevent hunting.

The direct current regulator which was developed first does not have any reaction in it to prevent hunting. It is the simplest form of a regulator consisting only of a main control element and secondary relay system

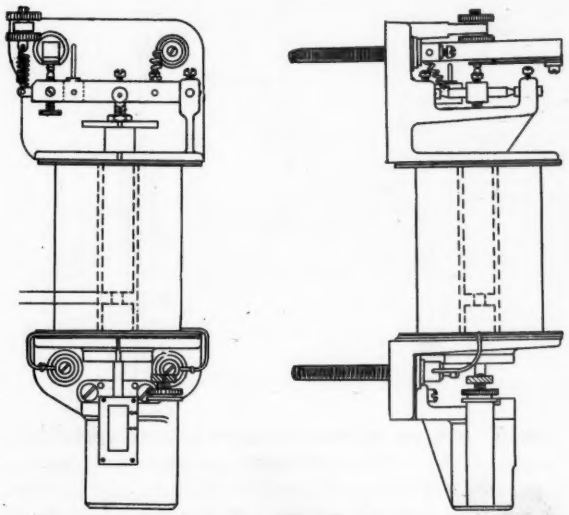


FIG. 3. CONTROL ELEMENT OF VOLTAGE REGULATOR FOR D.C. GENERATORS

which would temporarily short circuit the field rheostat. This regulator, you might say, hunts as it depends on an actual change in voltage before it will open its contacts. This will cause a flicker on tungsten lights but was not objectionable at the time it was developed, due to the fact that carbon filament lamps were in vogue. In ordinary power applications this slow rate of vibration or hunting is not objectionable, as the variation is hardly perceptible on the voltmeter and its only objection is when a lighting load is used. An improvement has been made in recent years and this objectionable flicker has been entirely eliminated from the direct current regulator.

Referring to Fig. 2, it is seen that the elementary regulator or the original direct current regulator consists of the main control coil E connected across the bus with the resistor 6 in series therewith. The contacts of this coil are in the circuit to the rheostat shunting relay which is differentially wound. That is, there are two circuits to the relay coils, which are split up to reduce the time constant and therefore make them vibrate at a faster rate. This high-speed or anti-hunting connection is the connection No. 4, which when the main contacts open, increases the voltage drop between the bus and terminal 1, thereby reducing the current through the main control coil E, causing the contacts to close. As soon as they close the drop on resistor 1 is decreased and the current in the main control coil E is increased which causes them to open; the net result

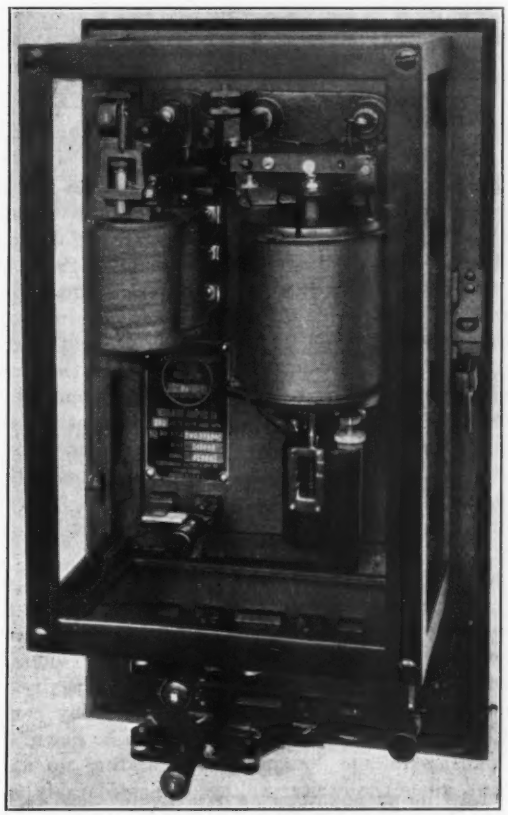


FIG. 4. A ONE RELAY REGULATOR

is that whenever the contacts either open or close a force is set-up which immediately opposes this action causing them to return to the original position. Thus the regulator vibrates at a very high rate of speed. The beat is in the neighborhood of 600 per min. Figure 3 shows the main control element of this regulator and the design incorporates a stop core, i. e., air gap, within the coil which increases the pull of the magnet and thereby increases the sensitivity. By the use of a stop core, the magnet has a pull curve which is very steep and this fact combined with the additional ratio of friction to torque makes the regulator very sensitive. Figure 4 is the actual photograph of a one relay regulator. It is to be noted that the disconnect switch inside of the case removes all of the direct current power from the regulator and was placed in this position so that the operator would not pull this switch by mistake for the rheostat shunting relay contact switch shown below the case.

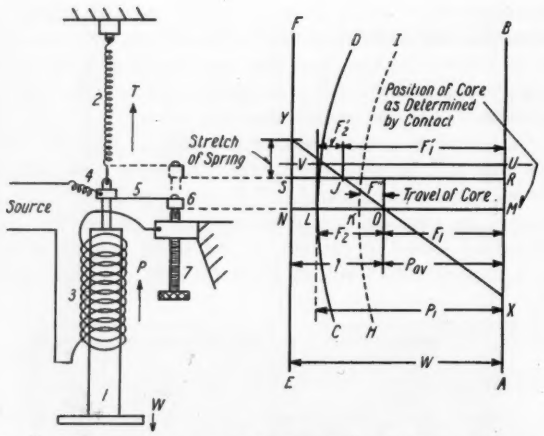


FIG. 5. DIAGRAM OF AN ELEMENTARY ELECTRIC VIBRATOR

The first regulator for alternating current machines consisted of the conventional direct current regulator energized from the alternating current transformer and the contact connected across the rheostat in the field of the alternator. This functioned very well but of course it was not able to handle very much current on the contact and inasmuch as the alternator field currents are high, it was obviously limited to only the smaller sized units. The next step in this development was connecting the contacts across the rheostat in series with the field of the exciter. This regulator obviously would not work inasmuch as it went to the point B and then opened up the contacts but the inertia of the system caused the outfit to travel on and the net result was the hunting.

Analyzing this action further, it is seen that when the relay contacts across the exciter field rheostat are closed and the system is in the act of building up and when the line voltage reaches the proper value, the main control magnet will open its contacts against tension of the spring, thereby opening the relay contacts and causing the exciter to begin to build down. The alternating voltage does not stop building up at this instant, since the exciter voltage is considerably in excess of the voltage necessary to force the correct current through the generator field. That the exciter voltage can and does get considerably in advance of the generator field current is a fact when it is considered that

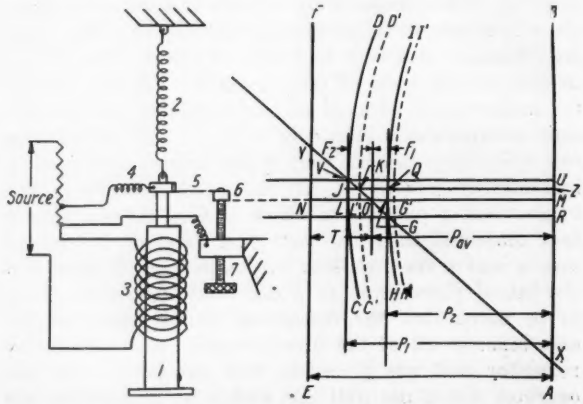


FIG. 6. ELEMENTARY VIBRATOR WITH CONTACTS BRIDGED BY RESISTANCE

in the act of building up, the exciter is compelled to supply a voltage equal to the drop in the alternating current field plus the inductive drop for the counter e.m.f. due to the increasing flux to the field winding. This inductive drop increases directly with the rate at which the exciter builds up. It is evident, therefore, that at the instant the line voltage has reached normal the exciter voltage is too high by an amount equal to the inductive drop in the generator field.

The alternator voltage therefore continues to rise above normal for some time, notwithstanding the fact that the relay contacts across the exciter rheostats are open. As a matter of fact, the alternating current voltage will increase and the exciting voltage will be decreasing. The reverse action holds true when the alternating current voltage has come down; that is, the contact will close when the alternating current voltage reaches normal and cause the exciter voltage to build up. Since the exciter voltage, however, is far below that necessary to maintain normal alternating current voltage the alternating current voltage will continue to decrease but the exciter voltage will be increasing. The

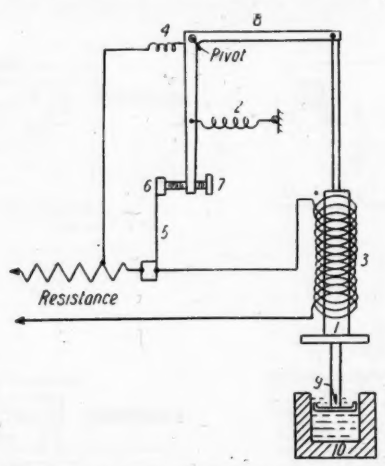


FIG. 7. DETAILS OF THE CONTACTS OF THE VIBRATING MAGNET

net result is that the system will never reach stability, always swinging above and below normal.

The solution to this problem is quite simple, although at the time it required considerable thought and effort as well as work in order to solve it. It was solved by placing a direct current voltage regulator on the exciter and instead of having the stationary main contact, this contact was placed on a lever which was controlled by the alternating current voltage. Thus a complete direct current voltage regulator was used and the alternating current magnet was used only to adjust the voltage for which the direct current magnet regulated.

The second regulator which Mr. Tirrill developed eliminated the direct current magnet and obtained the anti-hunting properties by a different means. Both control elements on the new regulator are controlled by the alternating current voltage, thus making the entire outfit independent of the exciter voltage. The interesting part of this new regulator is the vibrating magnet, as it is this magnet which has incorporated in it all of the anti-hunting features and which is the quick responding element. Figure 5 shows the schematic dia-

gram of elementary electric vibrator. In this case, it is seen that the weight of the core is down and the tension of the spring opposes the weight of the core. When the contacts are closed, a circuit is formed through them which energizes the coil causing the core to pull up and open the contacts. Immediately upon the opening of the contacts the magnetic pull is removed and the core then overcomes the tension of the spring; the vibrator then closes its contacts again. When the contacts close the core again jumps up, opening the contacts and this process is repeated, the vibrator continuously vibrating at such a time of contact engagement as to get the average pull of the magnet plus the spring tension to just equal the weight of the core. If this is shown graphically, we see that the weight of the core is EW, the tension of the spring is shown by the line YX, the maximum pull of the coil is P_1 and the average pull is P_{av}. The element is in equilibrium and vibrates at a definite time of contact engagement. Should the screw 7 be screwed up to the new position shown by the dotted line, the regulator will then vibrate at a different time of contact engagement in order to increase the

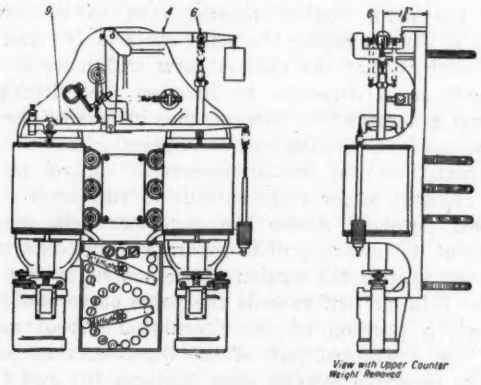


FIG. 8. MAIN CONTROL ELEMENT OF REGULATOR

average pull. This increase is shown by F_1. Thus we see that by merely changing the position of the contact screw we can change the time of contact engagement of this regulator or vibrator.

The next step in the development was to make this magnet so it would be more sensitive and this was done as shown in Fig. 6, in which case the contacts, instead of completely opening the circuit, only short-circuit a section of resistance in series with the magnet. The effect on the regulator (the principles and so forth are the same) is to make the regulator or vibrator more sensitive either to a voltage change or to a change in position of the contact screw 7. The next step in this development was to get the contacts and magnet in some form which it could be used and Fig. 7 shows this in detail. In this case the control magnet 3 is connected to the bell crank 8 which is pivoted at the panel at the point 4. The spring 2 assists the pull of the magnet. The contacts 6 and 7 short-circuit a section of the resistor in series therewith.

It is desirable in any regulator to have it errorless from no-load to full-load. This was obtained by using a main control magnet connected to the potential transformer which moved the main contact. Thus the vibrating magnet alone would cause an error in voltage from no-load to full-load but the fact that the main control magnet is balanced against the alternating current voltage by means of a counterweight and also due to the fact that the pull on this magnet is the same for the distance through which it travels there will be no error in the regulator from no-load to full-load. This is the only regulating device which is errorless from no-load to full-load, that is, inherently so. Instead of having the main contact control the resistance which is in series with the vibrating magnet it is desirable to have these contacts available for varying the exciter voltage so that the main contacts are connected to a group of relays, one of which short-circuits a section of the resistance in series with the vibrating magnet. Figure 8 shows

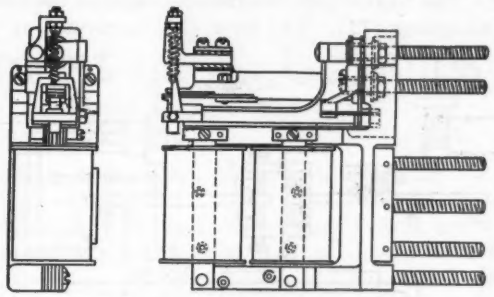


FIG. 9. DIFFERENTIAL RELAY

the way the vibrating and main control magnet are designed with the floating lever as item 9 and the bell crank as item 4. Note that connected to item 6 is a spring whose function is to take up any alternating current vibration which may be transmitted from the core to the bell crank lever. This is necessary inasmuch as the lever ratio of the bell crank is one to one whereas on the main control magnet the lever ratio is a one to two, thus the alternating current vibrations are not felt at the main contacts.

Figure 9 shows the rheostat shunting relay and it is to be noted that the armature on this relay has no pivot, but that the pivot is obtained by having the flat springs, two horizontal and two vertical act as the pivot. Thus no wear is obtained and no maintenance on this joint required. The only place where this regulator or relay requires attention is at the contacts.

In the search for a fast regulator the early rheostatic regulator was set aside when the ingenious vibrating regulator was developed. The desirable qualities of the rheostatic regulator were not forgotten, so that in time the high-speed rheostatic regulator was developed. The rheostatic regulator does what an operator would do, except that the regulator operates the rheostat at higher speed than normal hand operation and it is always available for instant correction. The exciter voltage remains constant and makes possible the use of a floating storage battery or other reserve direct-current source for emergency excitation.

In Fig. 10, a diagram of the system as worked out is shown in which the alternating-current generator whose voltage is to be regulated is represented at (1). The exciter (2) supplies current for the alternating current generator field through the motor-operated rheostat (3). This rheostat is similar to the standard generator field rheostats usually supplied except that it has twice as many contact segments and the rheostat

arm is geared to make one revolution in from 5 to 8 sec. as compared with 30 sec. for a standard motor operated rheostat. The object of the increased number of contact segments is to secure smaller voltage steps.

The main control magnet (4) is energized from the terminals of the generator to be regulated. This magnet moves a lever pivoted at (10) and carries a pair of contacts (6) which play between the contacts (7) and (8). A counterweight (11) counterbalances some of the weight of the magnet core and lever. It is adjusted to balance the lever exactly when normal line voltage is impressed on the main control magnet.

The direct-current magnet (5) is energized by the voltage drop across the alternating-current generator field. The magnet pull is downward against the tension of the spring (12). The lever (14) is pivoted at (13)

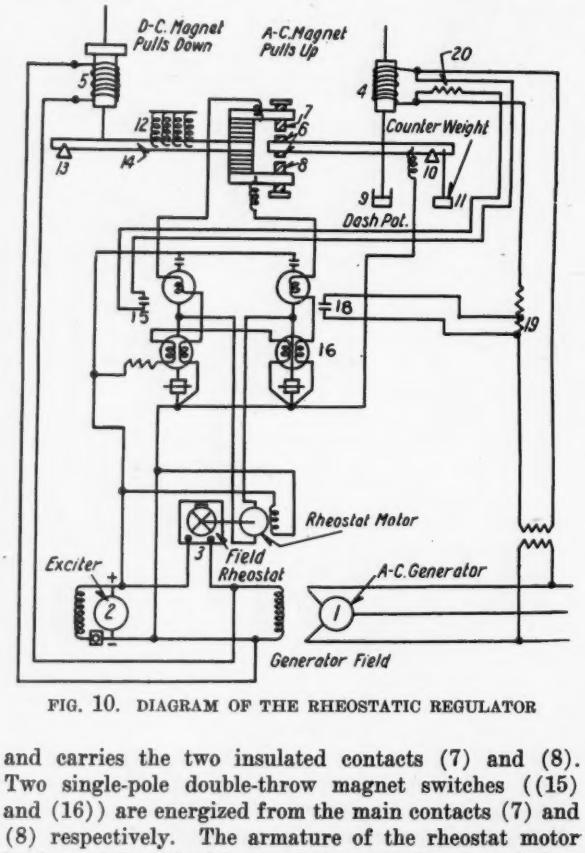


FIG. 10. DIAGRAM OF THE RHEOSTATIC REGULATOR

and carries the two insulated contacts (7) and (8). Two single-pole double-throw magnet switches ((15) and (16)) are energized from the main contacts (7) and (8) respectively. The armature of the rheostat motor is connected to the hinges of these single-pole switches. The upper and lower stationary contacts are connected to a source of constant direct-current such as the exciter. When the main contacts (6) and (7) close, the magnet of the switch (15) is energized, causing its upper contacts to close and the lower contact to open, thus completing the circuit from the positive exciter bus to hinge of switch (15) through the armature of the rheostat motor to the hinge of switch (16), through the lower contacts of switch (16) to the negative exciter bus. This causes the rheostat motor to run in a direction to lower the alternating-current generator voltage. If main contacts (6) and (8) close, magnet switch (16) closes its upper contact, thus completing the circuit from the positive exciter bus through the armature of the rheostat motor to the hinge of the magnet switch (15) and thence to the exciter negative. It will be observed that the current passes through the motor armature in the opposite direction, thus causing it to rotate in a direction to raise the line voltage. When main contacts (6) do not engage with either (7) or (8), both magnet switches have their lower contacts closed, thus short-circuiting the armature of the rheostat motor and thereby bringing the motor to a quick stop by dynamic braking. It will be noted that this switch group is very simple, yet performs the function of the usual double-pole reverse switch and dynamic braking contactors. These switches control the motor in either direction and in the "off" position short circuit the motor armature for dynamic braking. No interlocks are used and if both switches close simultaneously the motor is not connected to the line nor is the control bus short circuited. Thus with only two switches, no interlocks and sturdy constructions, reliable operation is obtained that is free from possibilities of short circuits.

It will now be apparent that for every position of the main control magnet core, there corresponds a definite position of the generator field rheostat, when the field current had reached its steady value. For, suppose the main control magnet core to be lowered slightly, thus engaging the main contacts (6) and (8), it is evident that the rheostat arm will move over its contacts in a direction to increase the alternating-current generator field current, thus increasing the drop across the field winding and consequently increasing the downward pull of the direct-current control magnet. The rheostat motor will continue to run until the increased potential across the generator field develops sufficient downward pull to separate main contacts (6) and (8) against the tension of the control spring (12). If the field current exceeds the value corresponding to the given position of the alternating-current magnet core the downward pull of the direct-current magnet will be excessive causing main contacts (6) and (7) to close which in turn closes magnet switch (15), thus moving the rheostat arm in a direction to lower the field current. The movement continues until the direct-current magnet is weakened sufficiently to separate main contacts (6) and (7) at which instant magnet switch (15) drops back and closes its dynamic braking contacts.

The action of the regulator as a whole will now be apparent. Suppose the line voltage to be below normal. This throws the main control magnet system out of equilibrium and allows the magnet core to move downward, at a rate proportional to the drop in line voltage, thereby closing main contacts (6) and (8). The rheostat arm immediately starts to move in a direction to raise the line voltage and continues to move until the line voltage is again able to sustain the weight of the alternating-current magnet core. Further downward movement, therefore ceases, thus disengaging main contacts (6) and (8), bringing the rheostat motor to a rapid stop.

In addition to the fundamental anti-hunting influence resulting from the reaction of the excitation voltage on the control, a further refinement is added to the rheostatic regulator, Fig. 10, to enable it cautiously to advance the field rheostat when small changes are required. This additional feature consists in equipping the contactor switches with auxiliary contacts insulated from the rest of the structure and arranged to

close when the switch closes. Each contact is connected in the circuit of the main control magnet in such a way that the closure of the auxiliary contact changes the strength of the main control magnet in a direction to open or tend to open the pair of main contacts whose engagement caused the contactor switch to close. For example, a slight reduction in the voltage will allow main contacts (6) and (8) to engage causing contactor switch (16) to close and start the rheostat motor to rotate in the raise direction. The auxiliary contacts (18) close at the same instant as the contacts of switch (16). These contacts short a small block of resistance (19) in the main control circuit. The drop in this resistance is small, so that the main control magnet is strengthened slightly. If the initial voltage drop is less than the drop across this resistance the main contacts (6) and (8) will open almost immediately, thereby opening the contactor switch (16). If the voltage is still low, the main contacts re-engage, thus causing the contactor to open and close in a vibrating manner, giving to the rheostat motor a series of impulses whose intensity diminished with the error in line voltage. Thus for small errors the auxiliary contacts enable the regulator to move the rheostat arm gradually without calling into play the more powerful influence of the direct current magnet. For large variations, however, the reaction of the direct current magnet is the sole stabilizing element.

This regulator has now been on the market several years and has been giving excellent service.

Use of Reclosing Equipment on A. C. Lines

From 75 to 90 Per Cent of Breaker Openings Are Caused by Temporary Faults Which Disappear After First, Second or Third Reclosure. By A. E. Anderson*

AUTOMATIC RECLOSING circuit feeders have had application on alternating current circuits for many years. Today the number of kilovolt amperes handled by these feeders is in excess of 2,250,000, the majority of installations being in the 2300-4000 v. distribution class.

An early type of a. c. reclosing feeder was obtained by adding two relays to an existing solenoid operated oil circuit breaker provided with over current protection. One of these added relays provided a time delay between the opening of the breaker and the subsequent automatic reclosure. A second relay in effect counted the number of breaker openings that occurred within a predetermined interval. If the overload persisted, the breaker would reclose a definite number of times and would finally lock out because of the action of the watching relay. Inspection and manual resetting of the relays was then necessary to put the feeder back into operative condition.

This equipment simulated manual operation. The breaker was reclosed a definite number of times regardless of circuit conditions.

Attempts have been made to "measure" an a. c. circuit (on stub feed) before the breaker is closed, in the same manner as is customary with a d. c. railway or industrial circuit but results have not been very successful for a number of reasons. Most a. c. circuits supply a load that consists chiefly of lamps. When the lamps are cold their resistance is 10 per cent or less of their "hot" value. If a small load indicating or measuring current is used, it is difficult to distinguish between a short circuit and useful load. Another requirement is the detection of high resistance cable faults. Such faults may not break down until practically normal voltage is reached. After breaking down, such faults have a low impedance. Although the measuring current and voltage may be increased, it has been found that the increased cost of the equipment does not warrant the advantages obtained over the equipment which recloses the breaker, regardless of circuit conditions.

Operating experience over a number of years has supported this conclusion. It has been found that from 75 to 90 per cent of the breaker openings are caused by temporary faults which disappear after the first, second or third reclosure.

A majority of the a. c. reclosing feeders are radial or stub. Where multiple feed is encountered, it is possible to use one of a number of solutions. It is the purpose of this article to deal only with the stub feed units.

In the development of a. c. reclosing feeders, as well as the various forms of automatic switching equipment, it was found that factory tests of the assembled unit had many advantages. This feature led to the development of a self-contained, a. c., reclosing feeder unit, completely assembled, wired and tested.

A. C. Versus D. C. Control—Tripping Schemes

Questions are frequently asked concerning the advantages of a. c. and d. c. control, with a. c. reclosing feeders. Generally speaking, a. c. control is used more frequently. D. c. control requires a battery with its resulting maintenance. The use of direct current was more common during the early application of a. c. reclosing feeders; however, the development of suitable a. c. operated devices and schemes finally resulted in the application of a. c. control to a majority of the installations.

Current for operating the breaker (closing) mechanism is obtained from a control power transformer connected on the source side of the oil circuit breaker. Current for tripping the breaker, on line overcurrent, is obtained from the secondaries of current transformers. The trip coil may be connected directly in the secondary circuit, giving instantaneous tripping upon the occurrence of overload. Again, it may be connected in parallel with a tripping reactor by means of an overcurrent relay. The latter connection is the more common.

From the point of view of closing current requirements, a number of features are in favor of a. c. control. The size of both the battery and control power transformer are determined principally by the maximum demand. Where a number of breakers are installed the cost of the battery increases very fast as compared with the cost of adding a few kv.a. to the size of the control power transformer.

The most common tripping scheme is obtained by the

*Switchboard Dept., General Electric Co.

use of inverse time limit overcurrent relays. At times, the trip coil of the breaker mechanism is connected directly to the secondary of the current transformer, giving the instantaneous tripping action. Undervoltage releases have had a very limited application and when so used have been in conjunction with feeders supplying certain types of motor load, which required an interruption of power supply for a definite time after a low voltage "dip." Trip coils actuated from line potential by means of overcurrent relays are not recommended, since under certain severe overload conditions

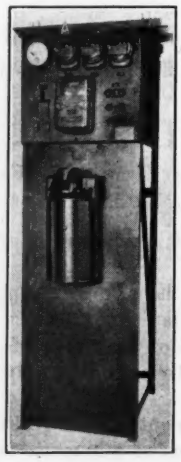


FIG. 1. TYPICAL INDOOR RECLOSING FEEDER PANEL, 4000 V., 3 PHASE

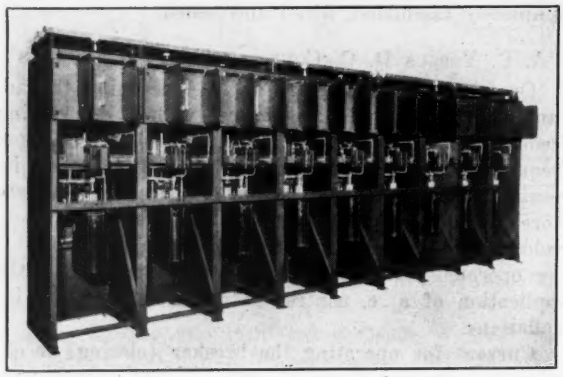


FIG. 3. REAR VIEW OF A GROUP OF RECLOSING FEEDER PANELS

the operating voltage is likely to go to such a low value that this coil will not operate.

Indoor Units

A complete line of a. c. reclosing feeders, of unit design, has been developed in order to meet different station layouts. The most common type is a self-supporting unit, as shown in Fig. 1. This particular unit is rated at 4000 v. and is equipped with an a. c. motor mechanism, described in a following paragraph. Inverse time limit overcurrent relays of the induction type are used. The reclosing relay, which is directly above the motor mechanism, is described in a following paragraph.

Figure 2 illustrates a number of these units, as installed. A superstructure has been added to the standard 90-in. unit to permit the use of a transfer bus with the necessary disconnecting switches. The superstructure is a part of the standard design and may be readily added to an existing 90-in. unit. The width of these units is 28 in. A steel apron is placed on the front of the unit, extending both up and down from the panel. This apron is used to prevent accidental contact with the live parts in back of the panel, and also improves the appearance of the unit. On the main supporting unit is mounted a set of single-throw disconnects, which are

FIG. 2. INSTALLATION OF AUTOMATIC RECLOSING FEEDER AT THE LYNN GAS AND ELECTRIC CO., SWAMPSCOTT, MASS.

connected in the feeder circuit. One oil circuit breaker is used to connect the transfer bus to the main bus, and is usually equipped with automatic reclosing features. Double-blade double throw disconnects permit a feeder to be transferred from one bus to another without dropping the load. Both blades are left in the same position when the switching has been completed.

Another view of a number of units, similar to those just described, is shown in Fig. 3. This is a back view, showing a number of 4250-v., single phase feeders. This particular design made use of a steel barrier between adjacent units. The protection afforded by the barriers has been felt in some cases to warrant the development of such a design. In most cases, however, this steel barrier has been omitted. This particular view also shows the main bus, feeder disconnecting switches, and potential transformers for the single-phase, watthour meters.

Obviously, there are a number of other methods of mounting such an equipment. Space does not permit illustrating these various methods, yet a few words may be added in order to cover a general description. Cell mounting of the oil circuit breaker and mechanism has been quite common, especially in the larger stations.

Another method has been to mount the breaker and operating mechanism back-to-back on a steel plate long enough to accommodate the various devices necessary to complete the reclosing feeder.

Another type, used frequently in the larger cities, is the truck-type panel design. Here the complete feeder is mounted on the truck. Connections are made from the removable truck to the stationary housing by means of major disconnecting devices. Connections for control power, remote indication, etc., are made through a set of minor disconnecting devices.

Figure 4 shows a modification of the truck-type panel design, as installed. In this view are shown two different types of trucks, one equipped with one triple-pole breaker and mechanism, and the other with three single-pole breakers and three mechanisms. The truck-removing mechanism is so interlocked with the control as to prevent automatic reclosure while the truck is being removed or replaced. This figure also illustrates

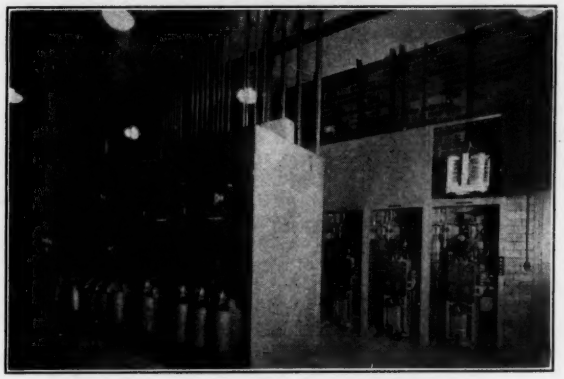


FIG. 4. AUTOMATIC SWITCHING EQUIPMENT OF CARRICK SUBSTATION, DUQUESNE LIGHT CO., SHOWING RECLOSING TRUCK TYPE OIL CIRCUIT BREAKERS

a method of mounting the induction voltage regulators and current limiting reactors. The control board of this particular installation is mounted remote from the truck panels.

Outdoor Units

The most frequent application of a.c. reclosing feeders has been to small, isolated communities having loads in the vicinity of 1500 kw. or less. Such feeders are of the outdoor type, illustrated in Fig. 5. It has been found that most outages on these circuits are caused by faults which are of a temporary nature. Such faults last long enough to trip the breaker, but disappear shortly after. Automatic reclosing features for such applications permit not only a prompt restoration of service, but also result in breaking up the system into smaller units than could be economically afforded by manual operation. This subdivision of the system leads to better operating results when a permanent fault has occurred, since a smaller portion of the system is affected. Another advantage of the switchhouse design—which is more or less dependent on its unit construction—is the fact that, in case the load should increase in later years so as to warrant the installation of larger units, or a substation building, the smaller unit can be readily removed to another isolated location.

The interior design of the switch house, illustrated in Fig. 5, is such that it will accommodate the more common breakers and various instrument transformer mountings. Two doors are placed on the front and back. These doors cover practically the whole height of the house, with the exception of a sill. This type of house is ventilated by means of a screened opening at the bottom and a ventilator placed on the roof. The high tension connections are made by means of a suitable number of bushings mounted on the roof. The control power connections (usually 220-v., single-phase) are made through a conduit fitting, on either side of the house, to a control power transformer of the usual

FIG. 5. SWITCHHOUSE MOUNTED A. C. RECLOSING FEEDER, 4000 v.

distribution type. In the ordinary application, six high tension connections, two low tension connections, as well as the ground connection, are made to the unit. All of the necessary devices, including instrument transformers, are located within the switch-house. Units of this type make use of the familiar panel-mounted (indoor) oil circuit breaker. Switch houses of this design have been applied to circuits as high as 13.2 kv., the more common voltage being 2300/4000.

Outdoor reclosing feeders of over 15-kv. rating make use of the standard, outdoor, oil circuit breaker. An enclosing case is attached to the front of the breaker framework. In this enclosing case are mounted the breaker closing mechanism, reclosing and necessary protective relays, as well as any instruments or meters. Units of this type have been applied to circuit voltages as high as 88 kv.

Editor's Note: This is the first of two articles on this subject. In a subsequent issue, the author will discuss, in detail, the principles of operation of reclosing equipment.

3300-Lb. Benson Boiler Operates Successfully

RESULTS SHOW EXCEPTIONAL SAFETY IN OPERATION AND FAVORABLE ECONOMY FOR 1½ YR.
NEW 2200-HP. BOILER UNDER CONSTRUCTION FOR SIEMENS-SCHUCKERT WORKS IN BERLIN

GENERATION of steam at high temperatures and pressures involves two difficulties: one the formation of steam bubbles on the tube walls with insulating effect so that these bubbles must be immediately removed to prevent overheating; the second that priming will result at high pressures if more than 125 cu. ft. of steam are disengaged per hour per square foot of surface. Natural circulation cannot meet these difficulties and various methods have been devised to overcome

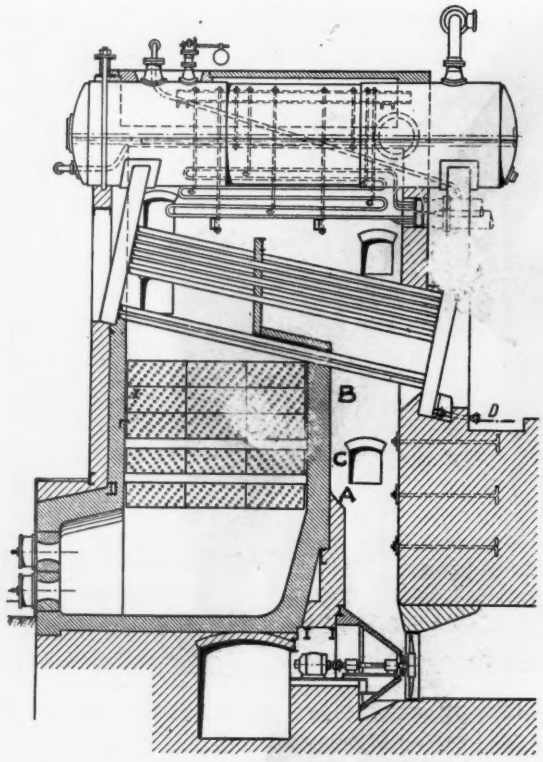


FIG. 1. CROSS SECTION OF BOILER UNIT, THE BORSIG BOILER ABOVE AND NESTS OF TUBES OF THE BENSON BOILER AT TOP OF COMBUSTION CHAMBER

them, one of these being that suggested by Mark Benson of evaporating the water under critical conditions of temperature and pressure. Critical temperature of water is at 705.2 deg. F. and the corresponding pressure 3295 lb., water changing into steam under these conditions without the addition of heat of evaporation. Water is simply heated up to the critical temperature and turned into steam with the slightest decrease of pressure, the resulting steam being afterward superheated. Because the heat of the liquid increases and the heat of evaporation decreases as temperature rises, the total heat to make a pound of steam at a temperature of 750 deg. or above remains nearly constant for all pressures above about 1470 lb. per sq. in. In the Benson boiler water is forced at a greater pressure than 3295 lb. through a heated coil, being gradually heated to a temperature of 705.2 deg., passes into steam and then is superheated by the further application of heat.

700-HP. BOILER FOR TESTS

Experiments on a laboratory scale were conducted in England in 1924 with a boiler of this type and, at the close of that year, a plant with a capacity of 22,000 lb. of steam an hour was erected for test purposes by the Siemens-Schuckert Works in Berlin, the steam to be throttled to 1470 lb. and 750 deg. F. for delivery to the turbine which produced 1000 kw. at 10,000 r.p.m. with speed reduction to 3000 r.p.m. for the generator.

To save space, an existing boiler was used as a feed water heater. This was of Borsig inclined tube steam drum type with heating surface of 3283 sq. ft. and operating on 191 lb. pressure. It was raised as far as the boiler house roof permitted and the tubes of the Benson boiler placed in the first pass beneath it, as shown in Fig. 1. Because of easy regulation and adaptation to limited space, oil firing was used for the test operation.

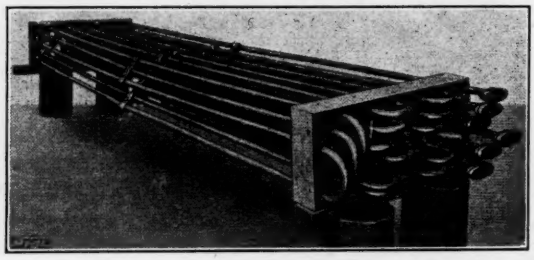


FIG. 2. TUBES ARE ARRANGED IN BUNDLES AND CONNECTED IN PARALLEL

Cold water is preheated in the Borsig boiler to a temperature of 355 deg. F. It is then fed to the Benson boiler by a high pressure pump, being sent to section A, which comprises 1/5 of the Benson boiler surface and heats the feed water to a temperature of 700 to 715 deg. at a pressure of 3307 lb. It is then passed through connecting tubes to section B of the boiler which comprises 3/5 of the heating surface. Here it flows counter to the flue gas current and is superheated to 752 deg. F., then collected and throttled to 1540 lb. and 600 deg. F. At this pressure it is sent to section C of the boiler which operates simply as a superheater and delivers steam to the turbine at 1470 lb. and 752 deg. F. The total surface of the Benson boiler is 2325 sq. ft.

No steam or water drums are used in the Benson boiler, evaporation and superheating all occurring in the tubes which are 0.7874 in. inside and 1.26 in. outside diameter. To give proper steam and water velocities, three tubes are put in parallel in a circuit in the water section A and 9 tubes in parallel in the steam sections. Tubes are arranged in bundles as shown in Fig. 2, each bundle consisting of three parallel wound tubes with intake and discharge flanges side by side. The straight sections are connected by tube bends with flanged ends, are located on the boiler frame with no solid connections so as to permit free expansion and are kept in alinement and spacing by cast-iron bands. Appearance of

the ends of the tube bundles is shown in Fig. 3, these being covered by a single row of bricks. Construction of the flanged joints is shown in Fig. 4, the hub flanges being loosely screwed on the tubes and the joint made by a packing which bears on the ends of the tubes. To allow for pressure and temperature fluctuation, long flange bolts are used with spring washers placed under the nuts. The same kind of joint is used in the steam main leading to the turbine.

There is no such thing as water level in the boiler, since the point at which water changes into steam varies according to the load on the boiler, therefore no water gage is possible and a Venturi meter was installed in the high pressure feed line to measure the rate of feed water flow. Hand or automatic control must be used to keep delivery of fuel and water in conformity and

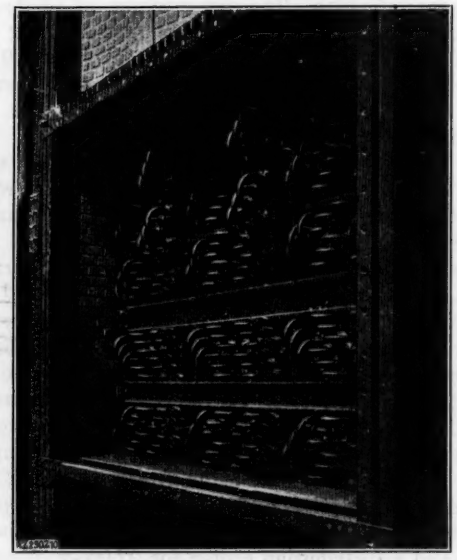


FIG. 3. END VIEW OF THE BUILT-IN TUBE NESTS

maintain the critical pressure of 3295 lb. in the superheater at all loads. Hand-regulated and automatically-regulated feed valves are installed in series at D, Fig. 1 and overpressures in the boiler and the feed pump line are prevented by two safety valves set for pressures of 3380 and 1470 lb.

For the high-pressure feed a plunger pump of hydraulic type is used, taking water at from 147 to 176 lb. and delivering at 3454 lb. at full load. It is belt-driven by a direct-current motor, controllable for widely variable speeds, and at full load requires 85 kw.

Most of the dissolved and suspended matter precipitates in the Borsig boiler so that only a slight amount of impurities enters the high pressure pump and it is found that these are largely carried along with the steam so that there are no extensive deposits in the Benson boiler circuit. Provision is made, however, for blowing down under operation. Instruments are installed for measuring the flow of feed water to the Borsig and the Benson sections and also the flow of steam from the Benson boiler, as well as the temperatures at these various points, so that a good understanding can be had of the amounts of water and steam flowing and the temperatures maintained.

Because of the small water volume in the boiler it can be quickly brought to full load, the time required, if hot water is used, being 10 to 12 min. It can also be shut off instantly without increasing the temperature in the tube walls.

Explosion Is Harmless

To determine what would happen if the tubes became clogged, cold water, which had not been preheated, was passed to the Benson boiler, allowing the precipitate

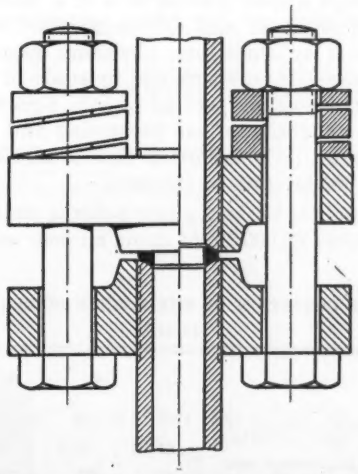


FIG. 4. SPECIAL FLANGE JOINTS ARE USED FOR CONNECTING TUBES

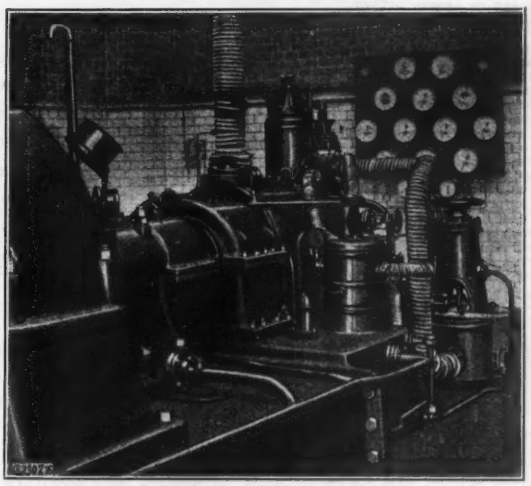


FIG. 5. TURBINE FOR 1500 LB. PRESSURE AND GAGE BOARD WHICH RECORDS STAGE PRESSURES

to clog the tubes so that one exploded due to high temperature. The pipe break was indicated by a hiss which killed the fire without causing the flame to backfire into the burner and the escaping steam and water passed to the chimney, no injury being done except the small break in the tube. This was repaired by cutting out a 3.25-ft. section of tube and welding in a new section, and the boiler placed in service next day. The break which was 1.5 in. long proved clearly that it was due to excessive temperature which caused the metal to melt as indicated by the knife-sharp edges, the indi-

cations being that the temperature was about 1200 deg. F.

The table shows results obtained during eight hours' operation under various loads, the temperature measurements being accurate to within 2 per cent and pressures within 1 per cent.

To use the steam at 1470 lb. pressure and 752 deg. F. a high-pressure turbine was installed exhausting at 191 lb. back pressure into the normal pressure system. It has nine stages, runs at 10,000 r.p.m. and is geared down through a spur gearing to a d. c. generator running at 3000 r.p.m. and delivering 1000 kw. Speed regulation is by throttling. Pressure gages are connected to the various stages and by study of the results obtained and possibly the use of still higher pressures, also by the adoption of air preheating and feed water stage heating, it is estimated that a result of 11,600 B.t.u. per kw-hr. can be obtained.

As a result of the test, a new boiler is under construction to deliver 66,000 lb. of steam an hour at a pressure

RESULTS OF OPERATION OF THE BENSON BOILER AT VARIOUS LOADS

	1	2	3	4
Steam Generated, lb. per hr.	8700	12,900	16,400	20,750
Feed water temp. to Borsig boiler, deg. F.	68	71.5	73.5	71.5
Water to high-pressure pump, lb. sq. in.	60	111	138	138
Water to high-pressure pump, temp. deg. F.	281	330	350	350
Water to Benson boiler, lb. sq. in.	3270	3260	3260	3270
Water to Benson boiler, temp. deg. F.	285	330	351	351
Steam from section B to reducing valve, pressure lb. sq.in.	3220	3140	3020	2960
Steam from section B to reducing valve, temp. deg. F.	738	738	734	716
Steam leaving reducing valve, pressure lb. sq. in.	1450	1450	1470	1510
Steam leaving reducing valve, temp. deg. F.	590	590	590	590
Steam delivered by Benson boiler, pressure lb. sq. in.	1420	1415	1420	1405
Steam delivered by Benson boiler, temp. deg. F.	750	765	765	750
Power hp. pump, kw.	31.7	46.4	60.2	79.6
Fuel oil lb. per hr.	1110	1490	1765	2160
Burners used	4	4	5	6
Flue gas, temp. deg. F.	375	415	490	530
CO_2 in flue gases, per cent	11	11.5	12	12.2

of 2646 lb. and 788 deg. F. at the turbine. It is estimated that Benson boilers for the pressures used can be constructed at about the same cost per horsepower as high-pressure boilers for 500 lb. and furnish a method for utilizing steam of the highest temperatures and pressures which can be handled with metals now available.

LOUIS BERNHARD of Boston, Mass., has patented a herring bone firebox, having the walls laid up of brick, set at an angle to the inside of the box and alternate courses with reversed angle. The wall is two brick deep, inside and outside tiers being at reversed angles, thus giving the herringbone effect. The result is interstices between the bricks of the two tiers and continuous vertical pockets with horizontal recessions on the inner wall. The interstices and pockets are to be filled with a high-temperature cement thus giving a large gripping area for this cement lining. At intervals binders are placed from the outer firebrick tier to the red brick outer wall to hold courses together.

Large Generator and Auto-Transformer

WITH THE STARTING of the new 60,000-kw. turbo-generator recently, the capacity of the Charles R. Huntley station of the Buffalo General Electric Co., at Buffalo, has been increased to 155,000 kw. This steam plant formerly known as the River Station has been in operation 10 yr. and is used as a steam auxiliary on a large hydroelectric system, to carry the normal peak loads as well as peaks brought on by emergencies. The plant, therefore, has a wide variation in load during the 24-hr. period.

As it now stands the station includes five steam turbine generators: three 20,000-kw. units, one 35,000-kw. unit and the new 60,000-kw. unit, all of General Electric manufacture. The new machine, of single-unit type, is one of the largest now in service using this form of construction. It is rated 66,667 kv.a., 90 per cent power factor, 1500 r.p.m., 25 cycles, and operates at 250 lb. gage, 250 deg. F. superheat, and one inch absolute back pressure.

The equipment includes a solenoid-operated valve which permits automatic adjustment of the load from a wattmeter relay, to hold a constant load on the turbine itself or on some other source of power in parallel with it. The operation of this feature in no way interferes with the action of the speed governor. The closed system of ventilation is used for cooling the generator, with surface air coolers and external motor-driven blowers.

Although the generator is rated at 12,000 v., to correspond with the previous machines, it is not connected to the 12,000-v. station bus but is solidly connected to an auto-transformer which steps the voltage up to 22,000. Connection is then made directly to the 22,000-v. buses of Station "C," adjacent to the steam plant, which is a tie-in transformer station with the Niagara system and a distribution center for 22,000-v. power in Buffalo. The old section of the steam plant is also tied to the 22,000-v. bus through transformers.

The auto-transformer is a General Electric three-phase, water-cooled machine, rated 25 cycles, 66,667 kv.a. output, 12,000/24,500 v., and is believed to be the largest transformer in America, both as to capacity and physical dimensions. An unusual feature of the design is that each winding is divided into two parallel circuits which are switched separately. The transformer is laid out to give a considerably increased reactance with half the winding in circuit. By means of suitable relaying, one of the parallel circuits is opened before the other in case of trouble, resulting in a reduced interrupting capacity requirement for the oil circuit breakers. There is also the possibility that under certain conditions it may not be necessary to open the second circuit, and the turbine can then be put back on the load with a minimum delay.

The boiler equipment which was added with the new turbine is also interesting in that it is a pioneer installation in the central station field of well-type furnaces and individual pulverizing equipment for each boiler.

MANY FAULTS are excusable; carelessness and neglect are not.

Reliability of Hydro-Electric Units*

ANALYSIS OF OUTAGE TIME WITH RESPECT TO AGE AND CAUSES OF OUTAGE, FOR UNITS OF 5000 KW. AND OVER IN 1925

THIS REPORT presents the results of the second year's study of the reliability of hydro-electric units by the N. E. L. A. Hydraulic Power Committee. As a result of the experience in preparing and collecting the 1924 data, the committee felt that greater value would accrue from limiting the investigation to the larger and more recent units; it accordingly directed the subcommittee to restrict its consideration of the 1925 records to units of 5000 kw. or above, installed not earlier than 1920. Had this procedure been followed in connection with the 1924 data, it would have eliminated 35 units, leaving, instead of eight impulse wheels and 48 reaction turbines, one impulse wheel and 20 reaction turbines.

TABLE I. PRINCIPAL CHARACTERISTICS OF HYDRO-ELECTRIC UNITS, 1925 DATA

Group Reference No.	H.P. of Each Turbine	Turbine Type	Vertical or Horizontal	Number of Runners	Rated Head, Ft.	R.P.M.	Year Installed	Rating of Each Generator, Kw.	Number of Units in Group
1	11,000	Reaction	Vertical	1	265	360	1922	7,500	2
2	11,000	Reaction	Vertical	1	268	327	1922	8,000	1
3	10,000	Reaction	Vertical	1	94	185	1921	7,200	1
4	14,000	Reaction	Vertical	1	94	150	1924	10,000	1
5	15,400	Reaction	Vertical	1	197	300	1924	10,000	2
6	11,000	Reaction	Vertical	1	75	135	1924	9,600	2
7	15,500	Reaction	Vertical	1	74	120	1924	12,000	1
8	13,400	Reaction	Vertical	1	64	105.8	1922	10,000	1
9	23,500	Reaction	Horizontal	2	172	200	1924	17,500	1
10	18,600	Reaction	Horizontal	2	125	200	1922	10,000	1
11	20,000	Reaction	Vertical	1	140	171.5	1925	13,500	1
12	20,000	Reaction	Vertical	1	140	171.5	1925	13,500	1
13	15,000	Reaction	Vertical	1	216.8	225	1921	12,500	1
14	15,000	Reaction	Vertical	1	197.9	225	1921	12,500	1
15	40,000	Reaction	Vertical	1	454	257	1922	35,000	2
16	9,500	Impulse	Horizontal	1	1865	514	1921	7,500	1
17	12,000	Reaction	Vertical	1	272	257	1921	10,600	1
18	15,000	Reaction	Vertical	1	...	...	1920	14,200	3
19	28,000	Impulse	Horizontal	1	1750	300	1923	20,000	2
20	70,000	Reaction	Vertical	1	213.5	107	1924	52,000	1
21	30,000	Reaction	Vertical	1	213.5	107	1924	52,000	2
22	8,700	Reaction	Vertical	1	180	360	1923	6,000	1
23	41,000	Reaction	Vertical	1	145	138.33	1921	30,000	1
24	4,800	Reaction	Vertical	1	55	138.5	1923	6,000	3
25	20,000	Reaction	Vertical	1	62	94.7	1924	12,000	1
26	20,000	Reaction	Vertical	1	62	94.7	1924	12,000	1
*27	22,500	Impulse	Horizontal	2	1900	375	1923-1925	17,500	2
28	22,500	Impulse	Horizontal	2	1680	375	1924-1925	17,500	2
29	30,000	Reaction	Vertical	1	680	428	1921	25,000	1
30	22,500	Reaction	Vertical	1	820	(500-600)	1922	17,500	2
Average of 43 units	21,684							16,642	

TABLE II. SUMMARY OF OPERATING RECORDS

	Hydro-electric Units									Steam Units
	1924						1925			1923
	All Units			Restricted as in 1925						
	Impulse Wheels	Reaction Wheels	Total	Impulse Wheels	Reaction Wheels	Total	Impulse Wheels	Reaction Wheels	Total	
1. Number of units included	8	48	56	1	20	21	7	36	43	87
2. Average turbine rating, h.p.	10,080	18,070	16,930	17,500	21,023	20,855	22,214	21,594	21,684	38,600
3. Service time, %	51.39	81.25	76.98	61.2	77.06	76.30	78.05	81.32	80.79	72.4
4. Idle time, %	48.61	18.75	23.02	38.8	22.94	23.70	21.95	18.68	19.21	27.6
5. Outage time, %	3.55	5.73	5.40	6.5	7.37	7.32	1.84	4.42	3.99	12.9
6. Outage time when in demand	0.41	1.87	1.67	0.0	1.03	0.98	0.79	1.92	1.73	6.0
7. Outage time when not in demand	3.14	3.86	3.73	6.5	6.34	6.34	1.05	2.54	2.29	6.9
8. Reserve time (4−5), %	45.06	13.02	17.62	32.3	15.57	16.38	20.11	14.26	17.22	14.7
9. Demand time (3+6), %	51.80	83.12	78.65	61.2	78.09	77.28	78.84	83.26	82.62	78.4
10. Max. possible service time (3+8) or (100%−5)	96.45	94.27	94.60	93.5	92.63	92.68	98.16	95.58	95.01	87.1
11. Capacity factor, %	16.5	51.5	48.1	14.4	46.14	44.43	24.61	51.49	49.44	51.6
12. Output factor, %	32.2	63.3	62.6	23.5	59.88	58.24	31.53	63.32	58.51	71.3
13. Service demand availability factor, %	99.59	97.75	98.02	100.00	98.21	98.30	99.04	97.84	98.04	92.3

By comparison, 43 units are represented in the 1925 data, including practically all of those of 5000 kw. or above reported upon in 1924, several installed during 1925 and a number which were in service earlier but for which no reports were submitted in 1924.

A thorough definition and explanation of each term used was given in the report on the 1924 data, and it is believed unnecessary to repeat these in this report.

As shown in Table I, the generator ratings extend from 6000 to 52,000 kw.; the speeds from 94.7 to 600 r.p.m., and the heads from 55 to 1900 ft.

Table II contains a summary of data obtained from the various plants. They were divided into impulse and reaction classes; for purposes of comparison, the corresponding figures for the 1924 hydro-electric unit data are given, also the 1923 steam unit data. The 1924 hydro-electric data are given both in total, as they appeared in last year's report, and with the restrictions of the present year as to size and age of units in effect.

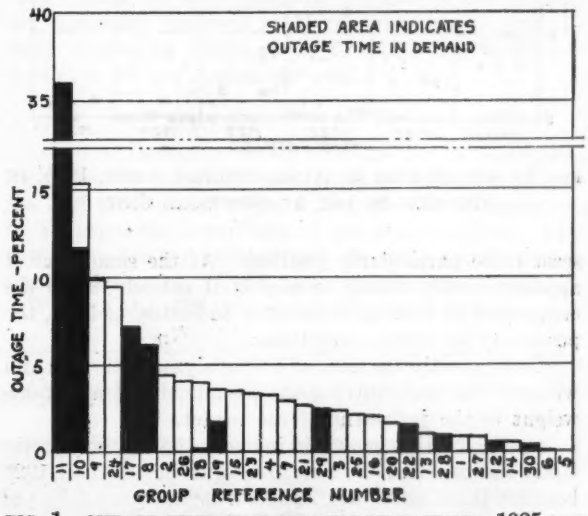

SHADED AREA INDICATES
OUTAGE TIME IN DEMAND
OUTAGE TIME - PERCENT
40
35
15
10
5
0
11 10 9 24 17 8 2 26 18 14 15 23 4 7 21 31 3 25 16 20 22 13 28 1 27 12 14 30 6 5
GROUP REFERENCE NUMBER

FIG. 1. OUTAGE TIME OF HYDRO-ELECTRIC UNITS, 1925, BY REFERENCE GROUPS

The 1923 steam unit record is repeated since no later data on steam units have been published.

The range of outage time percentage for 1925 is from 0.01 per cent to 36.16 per cent. Figure 1 indicates the total outage time and the outage time in demand for each reference group, in sequence according to the magnitude of the total outage time.

To test the existence of a relation between outage time and length of service, Fig. 2 and Table III have been prepared. In Fig. 2 the outage time percentages (both total and in demand) for each unit (not for each reference group) have been plotted against the year of its installation.

Table III places the same results in the form of average percentage applying to each year of installation; also, for comparison, including the corresponding values from the 1924 data.

Inspection of Fig. 2 indicates either a quite definitely upward trend with decreasing age, or no visible trend whatever, depending upon whether or not the single point in 1925 at 36.16 per cent is considered part of the data. This question is quite pertinent, since the particular outage mentioned is of a highly abnormal type, and, it is believed, should not be permitted to influence the average times as heavily as the other. Complete failure of the runner took place after about three months of operation. In view of the excessive outage time percentages (9.63 and 9.43), which would thereby be ascribed to units less than a year old, questions as to the propriety of including this unit would

*Abstract of report for 1926-27 of the Hydraulic Power Committee of the N. E. L. A.

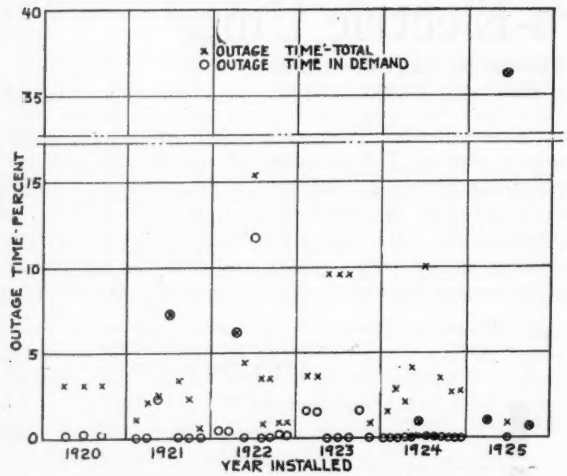


FIG. 2. OUTAGE TIME OF HYDRO-ELECTRIC UNITS, 1925, IN RELATION TO AGE, BY INDIVIDUAL UNITS

seem to be particularly justified. At the same time it appears equally wrong to neglect it entirely, since the occurrence of such an event once indicates, at least, the possibility of future repetitions.

Consequently the data will be analyzed both with and without this unit, leaving the assignment of a suitable weight to the judgment of the reader.

As Table III is given, it includes this doubtful unit. Upon its omission, the line for units installed in 1925 becomes three units, average total outage time 0.79 per cent, and average outage time in demand 0.52 per cent. The corresponding total figures are, respectively, 42 units, 3.23 per cent and 0.89 per cent.

The effect of thus modifying Table IV is similar to that noted above in regard to Fig. 2, namely, no trend is discernible upon examination. Analysis by the method of least squares discloses the existence of a very small upward trend in both outage times as the unit becomes older. Obviously, however, from any set of data, no presumption regarding the direction of trend is justified, when the trend is so indistinctly marked that rejecting a single unit of the set reverses its direction.

While the conclusion is almost irresistible that if the investigation were continued long enough, the outage time percentage would be found to increase with age, no definite tendency thus can be asserted from all of the data so far collected. The logical inference to be drawn is that in six years or less of operation, the deterioration suffered by modern hydro-electric units affects the outage time to an extent too small to be separated from the accidental variations.

Outage time percentages (of the reference groups this time) were plotted against the generator ratings (not shown). No least squares analysis of this relation has been made; but inspection shows a distinct decrease in outage time as the unit size increases. In this case, however, as in the preceding one, too much dependence should not be placed upon the accuracy of the indicated amount of decrease, in view of the magnitude of the accidental variations of individual groups.

Incomplete returns were received covering five reaction units, so that Table IV includes a total of only 38 units—7 impulse and 31 reaction. These figures show that during 1925 water-wheels and their auxiliaries were responsible for more than half of the outage time for both types of unit. The largest single cause in this class, for the reaction group and for the total, is the

TABLE III. AVERAGE OUTAGE TIME CLASSIFIED BY YEAR OF INSTALLATION

Year Installed	1925 Data			1924 Data		
	Number of Units	Average Outage Time, %		Number of Units	Average Outage Time, %	
		Total	Demand		Total	Demand
1920	3	3.19	0.20	4	3.63	0.55
1921	7	2.74	1.37	5	12.39	2.27
1922	9	3.98	2.07	5	1.88	0.64
1923	7	5.46	0.73	6	10.33	0.65
1924	13	2.36	0.08	1	0.8	0.8
1925	4	9.63	9.43	....	....	....
	43	3.99	1.73	21	7.08	1.02

TABLE IV. ANALYSIS OF CAUSES OF OUTAGE IN PER CENT OF TOTAL OUTAGE TIME

	Impulse Wheels	Reaction Turbines	All Hydro-Electric Units
Number of units included	7	31	38
General Hydraulic Causes:			
Ice or trash	....	1.2	1.1
Floods	....	0.2	0.2
Penstock or canal	32.9	8.8	11.0
Headgates or intake	....	0.9	0.8
Other general hydraulic	2.1	0.3	0.5
Total general hydraulic	35.0	11.4	13.6
Water Wheels and Auxiliaries:			
Runner	....	35.0	31.9
Turbine shut-off valve	6.3	...	0.6
Turbine gates or needle nozzle	....	1.2	1.1
Guide bearings	0.6	3.2	2.9
Thrust bearings	....	1.4	1.3
Governor and governor system	6.9	2.9	3.2
Pressure regulator or by-pass nozzle	17.0	1.0	2.4
Draft tube	....	0.4	0.4
Lubricating system	....	1.4	1.2
Vibration	....	....	....
Inspection	6.0	3.1	3.4
General overhauling	....	4.1	3.7
Other causes	15.9	7.9	8.6
Total water wheel	52.7	61.6	60.7
Generators and Appurtenances:			
Vibration	....	....	....
Lubrication or oil leakage	0.4	1.6	1.5
Rotor or field	3.6	1.4	1.6
Armature iron or windings	....	14.0	12.8
Exciter and rheostats	0.7	1.0	0.9
Ventilation system	....	0.0	0.0
Cleaning	1.9	5.1	4.8
Inspection	3.4	1.1	1.3
Other causes	2.3	2.8	2.8
Total generators	12.3	27.0	25.7
Total from all causes	100.0	100.0	100.0
Total outage in per cent of total time (Table III)	1.84	4.42	3.99

runner. As in last year's report, no outage time is reported for the impulse group due to runner trouble, the principal items being the bypass nozzle and other causes.

Second place in the reaction group and in the total is held by generators and their appurtenances, the armature accounting for approximately half of the class total. In the impulse group, however, this class is relatively small, second place being taken by the general hydraulic causes.

In the general hydraulic class the penstock or canal is responsible for almost all of the outage time of the class, for each of the groups and for the total.

One of the most interesting features of this report is the high degree of consistency to be observed between corresponding figures relating to the 1925 and to the 1924 data.

THE NORTHERN STATES POWER CO., Minneapolis, Minn., is planning to build two hydro-electric plants on the Mississippi and St. Croix Rivers. The first will be near Monticello, Minn., for a proposed ultimate capacity of 106,000 hp. The other near Nevers, Wis., will be designed for initial capacity of 28,000 hp.

ACCORDING TO THE REPORT of the Geological Survey, Department of the Interior, issued June 3, the production of electric power by public-utility power plants in the United States for April, 1927, was 6,369,870,000 kw-hr., an increase of 10 per cent over April, 1926. Of this amount 3,841,761,000 kw-hr. were generated by use of fuel and 2,528,109,000 kw-hr. by water power. Average production of electric power by public utility power plants for April was 212,000,000 kw-hr. a day, about 2 per cent less than the average daily output for March. The curve of average daily production of electricity indicates that the usual seasonal decrease in the demand for electricity occurred in March and April. Average daily output by water power in April was 84,300,000 kw-hr., or 40 per cent of the total.

CONSTRUCTION OF A FOUNDATION for a 23,000-hp. hydroelectric generator unit is in progress at Station No. 5 of the Rochester Gas & Electric Corp., Rochester, N. Y., below the lower falls of the Genesee River. The new generator will replace four old water wheels with a total capacity of 11,000 hp., according to Roger D. deWolf, of the electric department of the company.

Stevenson Creek Experimental Arch Dam Under Test

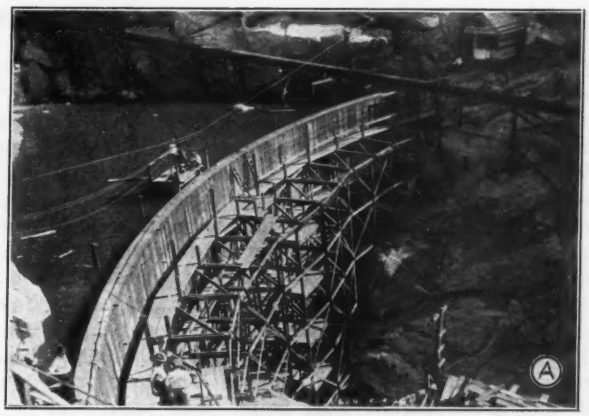
THESE RECENT photographs of the Stevenson Creek dam were furnished by the Engineering Foundation under whose auspices the dam was built and is being tested. A comprehensive progress report will be issued later in the year.

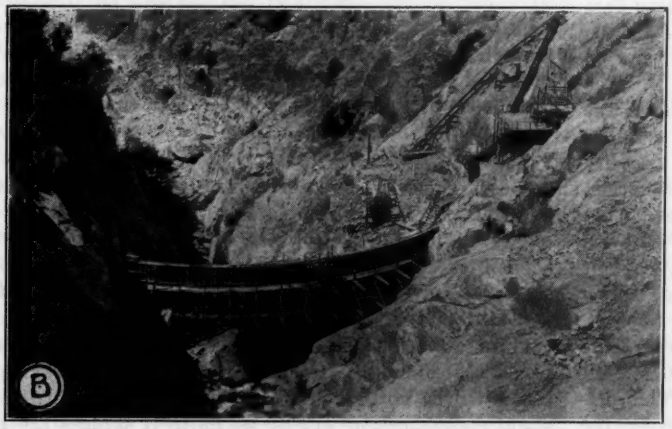
A—DAM COMPLETED TO HEIGHT OF 60 FT., WATER WITHIN 5 FT. OF TOP. VALVE PLATFORM FOR CONTROLLING DISCHARGE NEAR CENTER. STAGING ON DOWNSTREAM SIDE FOR CONVENIENCE OF ACCESS TO INSTRUMENTS AND MEASURING POINTS. INSTRUMENT HOUSE AT UPPER RIGHT

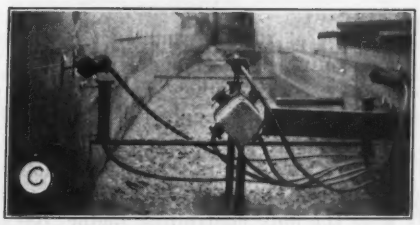
B—DAM LOOKING DOWNSTREAM SHOWING RESERVOIR AND 24-IN. WOOD STAVE PIPE FOR BYPASSING DRY WEATHER FLOW

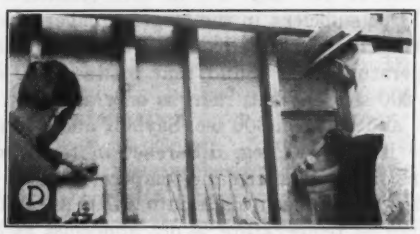
C—TELEMETERS AT EL. 10 FT. READY TO BE EMBEDDED IN CONCRETE AS DAM WAS BUILT 5 FT. HIGHER

D—AT LEFT, READING A TELEMETER. RIGHT, MAKING STRAIN GAGE MEASUREMENTS









Lubrication of Refrigerating Machinery

PROVISION OF AN OIL FILM BETWEEN MOVING SURFACES AND MAINTAINING THIS FILM IN GOOD CONDITION ARE TWO MAIN REQUISITES

LUBRICATION of Refrigerating Machinery was the subject of an interesting talk given by Raymond Haskell, industrial engineer with The Texas Co., at a recent meeting of New York Chapter No. 2 of the National Association of Practical Refrigerating Engineers. In this address Mr. Haskell pointed out in the beginning that there is little difference in the lubrication of a refrigerating machine and any other piece of high grade machinery having close clearances and working under a broad range of temperatures.

There are, broadly speaking, two requisites: (1) To provide and maintain a film of oil between all moving surfaces that will prevent solid friction; and (2) To keep this film of oil in such good condition that it will operate under the various conditions encountered.

The operating engineer, said Mr. Haskell, has little control over the method of distribution of the oil. This has been taken care of by the manufacturers. The engineer does, however, have control over the amount of oil that is fed to the various rubbing parts and it is his job to see that this amount is ample under the severest conditions.

No doubt the splash system of lubrication is the simplest but it also is the hardest to control and it may demand a larger separator or more than one to take care of the excess oil which may be fed to the cylinders. There is also a danger from violent churning which may cause emulsions or foaming if the oil is not refined to resist such mixing and promote separation.

While the lubricator system is more controllable, it is more complicated. As smaller quantities of oil are in use than in the splash system, the oil can be cleaned more easily as it has a longer time to rest. On the other hand, on account of the many points of adjustment, the responsibility of the operator is greater, yet he has an increased opportunity to give better service.

There are several factors upon which the maintenance of an oil film largely depend. The four principal ones are viscosity, flash point, pour point and emulsification.

Viscosity

As a general rule, in ammonia machines or others using low boiling liquids, we are inclined to believe that we need a viscosity higher than is necessary. In the compressor the gas temperatures are rarely over 300 deg. F. and generally not much above 200 deg. F. The wall temperatures naturally are much lower and if the viscosity of the oil necessary to lubricate the cylinder walls were the only controlling factor, 100 sec. viscosity Saybolt at 100 deg. F., in Mr. Haskell's estimation, would be sufficient in the larger number of cases. Considering the natural drop in viscosity of any oil with temperature, it is found that between 500 sec. Saybolt and 200 sec. Saybolt, there is only about 25 deg. difference, and between 300 sec. Saybolt and 100 sec. Saybolt, there is only 40 deg. difference in temperature. This means that by raising the temperature of a 300 sec. oil 40 deg. it has been made into a 100 sec. oil. This difference in temperature is not abnormal as between the wall temperature of an air compressor and the wall temperature of an ammonia or ethyl chloride compressor. It has been found by long experience that while a 300 sec. oil is perfectly satisfactory for an air compressor, a 100 sec. oil should be satisfactory for an ammonia machine. Since this difference may not always be present, as a safety precaution, an oil of 150 sec. viscosity is generally recommended with the usual run of compressors used in refrigerating machinery. Sometimes a 200 sec. or a 300 sec. oil is recommended but only to meet special conditions where temperatures may be excessively high and the bearings rather than the compressor control the viscosity necessary. The heavier oil does no particular harm except that it places an extra drag on the bearing and under the cold conditions of the condenser, it may not separate as easily from the ammonia or other medium as the lighter oil. If practical, it is best to have one oil for both bearings and cylinders even though the expense may be a little more because if an oil, which might "get by" on the bearings, should get into the compressor system, there might be trouble. Mr. Haskell, therefore, recommended a viscosity of 150 sec. oil for large compressors, and a 100 sec. oil for small compressors with a 200 sec. to 300 sec. oil for special conditions.

Flash Point

The flash point of an oil is practically of no consequence as far as the compressor end of refrigerating machinery is concerned. Flash point is only a measure of relative volatility at a fairly high temperature. It does not necessarily apply to the comparatively low temperature involved in this case. At the wall temperatures, the vapor pressure of lubricating oils is only about one thousandth of an atmosphere. This means that the amount of oil that actually goes into the gaseous form is so small in comparison to the amount of refrigerating medium that it scarcely needs consideration.

Pour Point

With regard to pour point, it is essential, said the speaker, to have an oil that will stay liquid at the lowest temperatures encountered so that it may drain off easily to the sump and not furnish an insulating medium which will cut down the transfer of heat from the brine to the cooling medium. It is particularly desirable that the oil not only shall have a sufficiently low pour test but also shall have a very low cloud test.

Emulsification

It is sometimes required in specifications that an oil shall have a good demulsibility or the power to separate quickly from water. While this will do no harm in a specification, it is not particularly valuable, as an oil may have good separating ability from water and still emulsify with ammonia or other refrigerating media. As a matter of practice, however, if oils are properly refined as discussed in a future paragraph, there will be no trouble due to emulsification. In fact, slight emulsification will do no harm if sludges are not formed.

Keeping the Oil in Good Condition

Although a plant may for a short time run on almost any good grade of oil, for economical reasons this oil should be kept in as high a state of purity as practical. Shut-downs cost money and may even endanger life if food products are involved. Let us therefore consider what characteristics an oil must have to allow of long time successful operation.

Refining of Oil

This brings up the matter of the refining of lubricating oil which is the most important characteristic that an oil should possess and unfortunately is one that cannot be covered with specifications. The most undesirable quality an oil may have is the tendency to formation in service of gummy deposits which collect on valves and in the cooling coils, preventing proper heat transfer and causing loss of efficiency. These may even get so bad at times as to plug up lubricating lines.

All oils when heated to 800 deg. F. or above break down into combinations of heavier and lighter products. This process may take place slowly even at lower temperatures and oxygen and some other substances called catalysts may accelerate the reaction. It is noteworthy, however, that there are several definite types of products contained in crude distillate that tend to coagulate or form gums sooner than others. These gums are immiscible in the oil and soon separate out. The object of refining of the oil is to remove the gum-forming bodies and the scientific refiner treats his oil so as to remove these undesirable constituents and leave a product less apt to change under operating conditions.

Cleaning the Oil

Nevertheless, in spite of the most careful refining practice, there are generally some constituents which will coagulate under service conditions and which must be removed before the oil can be reused. This is generally done by a cloth filter or a centrifuge machine. In this connection, attention is called to the fact that many of these undesirable constituents are soluble hot and insoluble cold and an oil should be filtered at as low a temperature as is practical without undue loss of time.

Acidity

Acidity, said Mr. Haskell, is a quality which is often looked upon with askance by specification lovers. As a matter of fact, acidity is not a dangerous property provided it is of a petroleum nature. In fact, petroleum acidity may improve the lubricating value or slipperiness of the oil and allow less wear to the machinery where pressures are high. Petroleum acidity or in fact any acidity will combine with ammonia at low temperatures to form soaps. As these are generally soluble in the oil they will do no harm as they will immediately break up into their original constituents in the hot part of the compressor. If the soaps are insoluble, they will be thrown out in the separator. This whole proposition, however, may cause little alarm because the actual amount formed will be too small to be considered.

There is little difference, however, between the problems involved with ammonia machines and those involved with the chloride or sulphur dioxide machines. The principal difference in treatment is due to the fact that ethyl and methyl chloride are completely soluble in oil when in the liquid form. For many years, on account of this mutual solubility, everybody thought we could not lubricate this type of machinery with oils, but seemed to forget that we have almost the identical problem in the lubrication of an automobile and the lubrication of this type of refrigerating machinery with oils is fully as successful as the lubrication of an automobile. While the liquid lubricating media may dissolve in the oil, it must be remembered that the solubility of the gaseous media is only slight and at the temperature of the compressor the refrigerating substance is practically always in the gaseous form. In the case of sulphur dioxide, also, the "bugaboo" was raised that there was reaction between the sulphur and sulphur dioxide. While this may be true at high temperatures, with a highly refined oil the reaction is so slow at low temperatures that enclosed machines can run for years using sulphur dioxide without any trouble whatever.

These types of machines are usually small and hence have not the bearing pressures of the larger machines. Normally an oil of 100 sec. viscosity at 100 deg. F. is recommended though some manufacturers have recently found that an oil of 50 sec. or 60 sec. viscosity at 100 deg. F. gives complete satisfaction with less drag on the bearing.

There is no objection to passing oil through water in the filtering process, because if cloth or paper is used this will not permit the water to pass along with the oil. In any case the water will settle on the bottom, the clean oil being taken off the top of a filter.

Pointers on Purchasing

AMONG INDUSTRIAL engineers prejudice against certain firms and hasty condemnation of an entire line through the failure of a single piece of equipment to uphold expectations is, unfortunately, the rule rather than the exception, particularly if the supplier is new to the user.

It should not be overlooked that all manufacturers of power transmission, material handling and power plant equipment, were, at one time, not widely known. The engineer who takes a negative attitude on a proposition merely because the salesman comes from a new house frequently denies himself the opportunity of obtaining excellent equipment.

Investigate the merits of each concern's products. Every firm just starting into business or opening relations with a new customer is keenly alive to the necessity for service and anxious that its products make good.

Engineers should retain all catalogs, go through them, then discuss with others in their organization the merits of the product. Salesmen are always glad to supply needed information, even though they realize no immediate sale is possible. Incidentally, the engineering staff and the purchasing department should work in close co-operation. Economy invariably results when group judgment is substituted for individual judgment.

Prime Movers Committee Reports on Boilers

IN ITS REPORT on boilers, superheaters and economizers for April, 1927, the Prime Movers Committee of the National Electric Light Association, 29 W. 39th St., New York City, has included a large amount of interesting and valuable data on the operation of some of the more important and recent power stations that have been under discussion during the past year. This report states: The installation of a 1390-lb. unit at Lakeside Station may be recorded as one of the outstanding achievements made during the past year. This installation is the second to be designed in this country for operation at a working pressure of 1200 lb. or over.

The 1200-lb. pressure installation at Edgar Station has now been in service for about one year. Operating experience with this unit indicates that, although the difficulties met with have not, to date, been entirely eliminated, they should in the future be at least reduced to the extent encountered in the lower pressure units.

Use of water walls has increased at a remarkable rate. There are two reasons for this wider application. The first installations were made primarily to reduce furnace maintenance through reduction of furnace temperature. It was later found, however, that water walls afford an exceedingly efficient heat absorption medium, and many installations are now being made from this viewpoint alone. Only a limited number of installations have been in service a sufficient length of time to afford very extensive operating data; however, the operating data at present available indicate that closest attention to circulation in the design of water screens is of paramount importance.

The tendency toward higher steam pressures and temperatures and higher rates of fuel input results in higher temperatures of the gas leaving the boiler; therefore, to maintain the high boiler efficiencies required by the commendable policy of fuel conservation, the use of air preheaters or water economizers or both is resorted to. This accounts for the increasing application of either or both of these heat reclaiming devices. In the latest installations, however, the tendency seems to be in favor of the air preheater, since utilization of the maximum available economies afforded by multiple bleed point cycles prohibits to a large degree the saving possibilities of the water economizer.

Trend in maximum evaporation per square foot of heating surface continues upward. This is the natural result of the desire to minimize space required and operating costs, and it also permits increasing the size of the prime movers, even though the available space for boilers per unit may be definitely fixed or limited; however, high ratings increase the possibility of solid matter being carried over into the prime mover.

Steam generator types of boilers, a new and recent development, present a design which, if their practical performance meets with the promises of their promoters, will be revolutionary and a direct result of the trend toward higher evaporation per square foot of heating surface and higher combustion of fuel per cubic foot of furnace volume. Although at the time of writing this report no steam generator installations are in operation in this country, several are now under construction and performance data on these are awaited with considerable interest.

Nothing of particular interest has been reported in connection with superheaters in new installations. The preference is probably toward the use of interdeck superheaters above the fifth or sixth row of tubes; however, application of radiant heat superheaters and convection type superheaters, separately and in tandem, continues. One notable installation of the radiant heat type of superheater is in the new high pressure unit at Lakeside Station of the Milwaukee Electric Railway and Light Co. Radiant heat superheater surface is installed on the two side walls with a radiant heat reheater in the rear wall.

Boiler rooms at a number of stations now consist of two sections which operate at different pressures. This type of layout necessitates the installation of a desuperheater in the inter-connecting tie line between sections. Performance data on desuperheaters are at present extremely limited, but it is hoped that information on some of the installations recently made or now under construction will be available in a comparatively short time.

More detailed discussion of some of the important parts of this report will be presented in later issues.

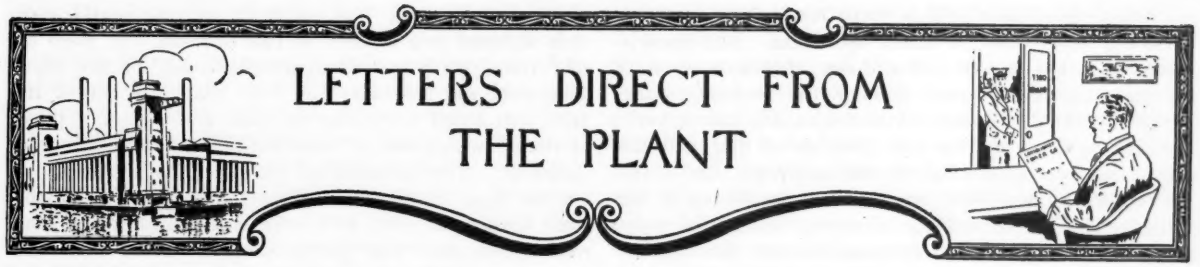
132,000-V. Oil-Insulated Cable for Underground Line

ALTHOUGH the precise details are not available at the present stage, much interest attaches to an oil-insulated, underground cable that has just been installed for the underground transmission line between the Hell Gate power plant in the Bronx, New York City, and the overhead transmission line which starts within the city limits of Yonkers and extends up through Westchester County.

The transmission line in question is a three-cable, 132,000-v. underground link through the two cities, coming above ground at Dunwoodie and then running on steel transmission towers along the right-of-way of the Catskill Aqueduct which brings the water supply to New York City. The cables are laid in concrete ducts, cast by machinery right in the trench. The cables are lead-covered, and between the lead sheathing and the cable proper is the oil bath which provides unexcelled insulation. The oil employed is a special mineral oil, and some 300 gal. are required per running mile of cable. Gravity tanks, installed in an attractive colonial style brick building at Lincoln Park, Yonkers, are depended upon to keep the cables filled with oil. The cables are 12 mi. long.

While an oil-insulated underground cable of this magnitude is an experiment in this country, it appears that the practice has been in use for some time in Italy. In fact, the present installation, undertaken by the General Electric Co. and the Pirelli organization of Italy, is under the supervision of Italian as well as American engineers.

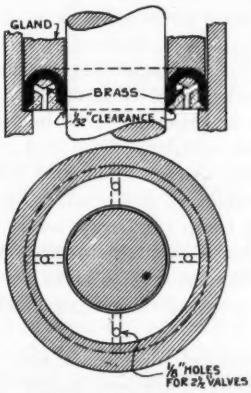
A. G. CHRISTIE, Professor of Mechanical Engineering, The Johns Hopkins University, Baltimore, Md., sailed for England on June 11 to be engaged until October as consulting engineer to British interests.



Packing for High-Pressure Water Lines

WITH REFERENCE to the article entitled "Proper Selection of Packing Avoids Trouble," printed on page 647 of the June 1 issue, I have used a 2500-lb. water system for 15 yr. and have found the leather cup method of packing described to be the least successful.

Instead of a cup leather, I use a "U" leather. This may have a little greater initial cost, but it is more satisfactory in operation. I find it just as important to prevent leakage next to the stuffing box walls as it is to prevent leakage next to the rod. In the packing as used



SHOWING HOW U LEATHER PACKING MAY BE APPLIED TO WITHSTAND HIGH WATER PRESSURE

by "J. A.," a leak, which may cause the washing out of the flax and collapse his leather, may occur around his packing.

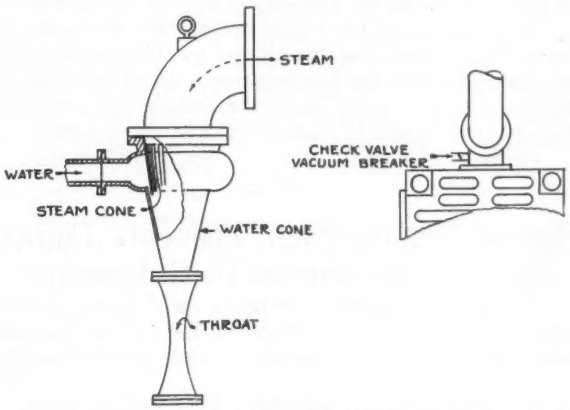
In my packing I use a bronze ring inserted in the "U" leather instead of flax, the ring being machined to fit the inside of the leather and perforated to equalize the pressure on the inside of the leather as shown in the illustration.

E. Chicago, Ind. JESS THOMPSON.

Comment on Water Backing Up Into Engine

BASED UPON an experience with barometric condensers covering a period of from 25 to 30 yr., I take exception to Alvin B. Kane's comment on page 264 of the February 15 issue.

Plugging up around the steam cone has nothing to do with water backing into the engine. If the throat or water cone became plugged, however, water would back up although in my experience I know of this happening only once. The plant in which this occurred was closed over the week end in twenty below zero weather. The throttle valve of the engine leaked more or less and the condenser throat frosted and then froze tight. When water was injected Monday morning, it came down the exhaust pipe but the main engine not being in operation, only small damage resulted. The exhaust pipe was 24 in. in diameter and the injection pipe 8 in.



SHOWING HOW CONES ARE LOCATED IN BAROMETRIC CONDENSERS AND WHERE CHECK VALVE SHOULD BE PLACED

Some engineers grind off the boss on the small end of the steam cone in order to increase the flow of water through this particular type of condenser. This forms a larger water inlet and sometimes floods the throat resulting in a new engine and a new engineer.

Drip and vacuum traps are supposed to be standard equipment where condensers of this type are used. Not only have heads been knocked out but turbine blades jarred loose when proper protection has not been afforded. As to the overflow in the hot well, even though the outlet were completely closed, water could overflow over the top of the hot well without backing up in the tail pipe. Small sized hot wells have caused a whirlpool to form, breaking the seal and allowing water to be drawn back when the engine was stopped, and wrecking it. It has become customary also to place a check valve between the throttle valve and the cylinder as shown in the illustration. Steam pressure holds the check valve shut, but when the throttle is closed the check valve opens, breaking the vacuum at the point where it is being generated.

Lawrence, Mass. TOM THUMB.

Effect of Hole in Tail Pipe of Barometric Condenser

WHAT HARM may be done if there is a hole in the tail pipe of a barometric condenser, is a question frequently asked in the engineer's examinations in the state of Massachusetts. As long as the condenser is

operating, the hole would perhaps lower the vacuum a little but otherwise not affect operation. The trouble comes when the engine is shut down; that is, as soon as the steam and water stop flowing, the momentum imparted by the descending water ceases, the atmospheric pressure tends to reverse the direction of flow and the air works through the hole in the tail pipe, due to the vacuum in the head and forces its way to the top of the water. The water and air mixture, instead of stopping at the height of 34 ft. continues on through the condenser head to the engine, the effect being the same as that of an air lift pump.

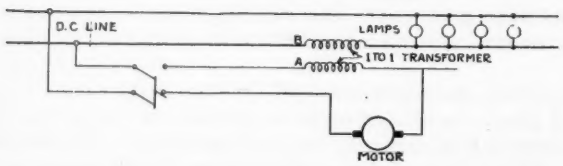
To prove this, if you fill a bottle nearly full of water, place the thumb over the mouth of the bottle, then invert the bottle and remove the thumb holding the bottle upside down, the in-rushing air will be seen to force the water up against the bottom of the bottle.

If the mouth of the bottle is immersed in a pan of water before removing the thumb no disturbance will be observed within the bottle except a slight lowering of the level of the water until the outside air pressure balances the height of water in the inverted bottle.

Springfield, Mass. WM. P. SLATTERY.

Special Transformer Prevents Lights from Flickering on D. C. Circuits

TO PREVENT flickering of lights on a direct-current circuit when a load is suddenly thrown on in parallel with them, a one-to-one transformer connected as shown



CONNECTION DIAGRAM SHOWING HOW 1 TO 1 TRANSFORMER IS CUT IN ON MAIN CIRCUIT AND ON SHORT CIRCUIT

in the drawing has given good results. With this arrangement, when the motor is connected to the line, the sudden rush of current through the coil A induces a voltage in the coil B which overcomes the momentary drop in voltage across the lights caused by closing the motor circuit. The proper size of this transformer is about 15 kw. for each 75 kw. of load added to the motor.

Woodward, Okla. H. J. ACHEE.

Home-Made Tachometer Sounds Alarms

IN A SMALL mill driven by a powerful overshot water wheel the miller was much annoyed by speed fluctuation. There was no speed indicator in the mill and the owner did not seem inclined to provide one. The miller and the millwright put their heads together and the latter tried to rig up a speed indicator similar to one described in these columns some time ago, where an old steam engine governor formed the base of the appliance.

Being unable to lay hands upon an engine governor, the millwright rigged up an appliance as follows: A piece of steam pipe was cut 3 ft. in length and both ends squared and reamed to full opening. A piece of cold rolled steel was fitted snugly inside of the pipe. This steel rod was also cut 3 ft. long. A hole 2 in. deep was bored vertically into the top side of a piece of timber which was to form the base of the new speed indicator. The diameter of the hole was about ⅛ in. greater than the diameter of the steam pipe. From the same center, another hole was bored, into which the cold rolled steel was driven snugly. Great care was taken to make the steel rod stand exactly vertical.

Into the bottom of the hole in the timber, a brass washer was fitted, the steam pipe was slipped over the rod and down upon the brass washer and a small pulley was clamped to the pipe an inch or two above the timber. A small belt around this pulley ran over another pulley located upon a nearby shaft. Later the diameters of these pulleys were changed to give a suitable rotative speed to the new speed indicator. The top of the pipe extended a little distance above the rod. A hole was drilled through the pipe close to its upper end, taking care that the holes in each side were diametrically opposite each other. These holes were tapped and into each was threaded a screw-eye. A bit of each screw-eye was hack-sawed away at the top so as to transform the screw-eyes into closely rounded screw hooks. Two pieces of ⅜-in. cold rolled steel were cut to a suitable length. Each rod could be from 18 to 30 in. long according to the ideas of the builder. One end of each rod was flattened to about $\frac{1}{16}$ in. thick and a hole was drilled through each flattened place which would enable the rods to be hung upon the screw hooks previously mentioned. The holes in each side of the flattened places on both rods were countersunk so as to prevent all possibility of the rods sticking or getting caught on the screw hooks.

When the vertical pipe shaft was rotated the suspended rods above described would have their lower ends thrown outward by centrifugal force, just as is the case with the balls of an engine governor. A slightly curved light iron bar was bent into shape and fastened in such position that the lower end of the rotating rod would clear the curved bar in whatever position the rods may chance to hang. One of the rods was then "upset" near its lower end and thereby shortened about ½ in. The mill was then started under its own power and the pulleys in our new tachometer belt drive were changed until the rods of our instrument would hang at about 45 deg. when the mill was running at proper speed.

Fastened to the curved bar in such a position that it would be struck by a revolving bar when the mill was running at required speed was a small sleigh bell. The other revolving rod was shortened to prevent its striking the bell. The object of the second bar was merely to act as a counter-balance to the rod which touched the bell, thereby securing smoother turning of the instrument than if a single suspended rod had been used. The millwright then arranged two other sleigh bells having tones different from each other and from the bell already in place. These new bells were arranged in such positions that they would be struck by the rod when the mill speed was 50 revolutions too slow or too fast.

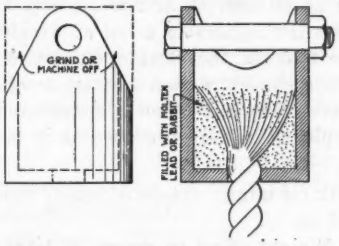
Attached to the curved bar slightly above the three

bells, was a little triangle made from ⅜-in. steel. When the revolving bar struck the steel triangle, the miller knew that the mill was running too fast and had reached a speed dangerous to some of the machinery. A signal sounder of different type was then fastened in place below the bells. This sounder was made of sheet iron and the millwright expended upon it all his ingenuity to make the device give forth, when struck, the most disagreeable and discordant sound possible. When this signal was sounded, it indicated that the mill machinery was running too slowly to do efficient work.

Indianapolis, Ind. J. F. HOBART.

Cable Ends Made from Scrap Parts

STEEL WIRE cable must be secured in a manner that will place an equal pull in each strand, if a permanent end connection is to be obtained. Bucket shaped attachments, in which the cable end is secured by lead,



SHOWING HOW SCRAP PART IS DRILLED AND GROUND AND AFTER INSERTION OF CABLE, FILLED WITH MOLTEN LEAD

are obtainable in some supply stores. These are designed for the specific purpose of making the end attachment as strong as the cable.

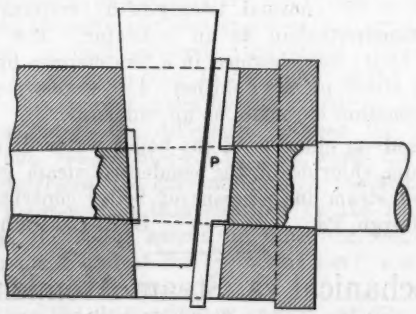
Recently, when fitting up a number of wire cable crane slings in a certain shop, the mechanic, not having the necessary special attachments and desiring to expedite the work, obtained from scrap some old discarded bushings. These bushings were attached as shown in the illustration, thus providing substantial substitutes, at no other cost than that of labor.

Washington, D. C. G. A. LUERS.

Removing Bound Piston Rods

SOME TIME AGO I had occasion to take the piston rod out of the crosshead of an old-fashioned slide valve engine; the end of the rod was tapered where it fitted into the shoulder of the crosshead and a key driven through the opening in shoulder and rod secured it in place. After knocking out the key, I tried to drive the crosshead off the rod with a heavy hammer but it would not move, not even after heating. I suppose the key way through the rod had become burred some way so I used two iron wedges made as shown in sketch, placing them in the opening as shown, with the projecting lug P in contact with the piston rod. After lubricating both surfaces of the tapered wedge, a few taps of a hammer loosened the rod and the rest was easy.

Buffalo, N. Y. G. J. BOWLES.



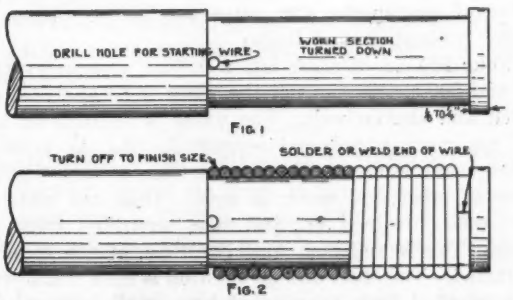
EXTRA WEDGE WITH PROJECTING LUG AIDS IN REMOVING STICKING PISTON RODS

Repairing Worn Journals by Wire Winding

THERE ARE many occasions for repairing worn shaft journals. A method I have frequently employed is demonstrated in the accompanying drawings. This method is particularly valuable for worn armature shafts and is superior to other methods I have seen used. It may often be used to save the expense of replacing engine crank shafts, line shafts and counter shafts where the journal is worn.

The worn section of the journal is turned down, as shown in Fig. 1, leaving a collar at the end. The diameter to which it is turned should be based upon the size wire to be used, allowing sufficient metal for turning the shaft to size after the wire is wound without cutting through more than half the diameter of the wire.

After drilling a hole into the journal at the shoulder, one end of the wire is inserted and the wire is wrapped under tension in a lathe, the coils being laid

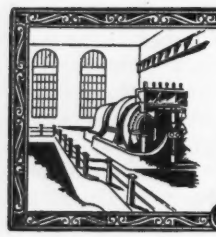


GOOD WEARING SURFACE ADDED TO WORN JOURNAL BY WIRE WINDING

close together in a manner used in making tight coil springs. Before cutting the free end of the wire, after running the full length of the turned section, it should be held perfectly tight to the shaft by means of a clamp to prevent unwinding. After cutting the end of the wire, it can be secured to the shaft by soldering in place or by welding with a torch.

The journal should now be $\frac{1}{16}$ to ⅛ in. larger than the finished size. It can then be turned down to the proper diameter. The result will be a nice smooth bearing having a much harder and longer wearing surface than the original. The small grooves between the coils left after turning make excellent oil pockets.

Syracuse, N. Y. H. L. WHEELER.



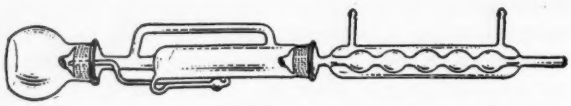
QUESTIONS AND ANSWERS

Refrigeration for Hardening Ice Cream

CAN ANY of the readers of Power Plant Engineering furnish me with information regarding the proper amount of refrigeration necessary to harden a given quantity of ice cream? J. M. C.

Factors Bearing on Proper Feed Water Treatment

ON PAGE 505 of the May 1 issue in the article "Factors Bearing on Proper Water Treatment" is mentioned the fact that the condensate had several grains per gallon of oil. May I ask what is the method used to determine



SOXHLET APPARATUS, USED IN FEED WATER TESTING

the quantity of this oil? Also, in regard to the statement—"condensed steam in per cent of boiler concentrations," how is this percentage obtained? G. G. S.

A. The method for determining the grains of oil, per gallon of condensate, for water *not* having suspended matter present, is as follows:

Pour 100 c.c. of ether into a 500-c.c. separatory funnel and 200 c.c. portions of the water to be analyzed are added and shaken well. The water is drained off and 200 c.c. more added and separated. As the ether is lighter than water and floats on top, a very distinct layer of ether and water is seen. Thus, the water is very easily drained off and thus separated from the ether. This is repeated until 1000 c.c. of the water is extracted. The ether and oil solution is then transferred to a weighed flask, evaporated to a small volume after which it is placed in a drying oven and heated at 90 deg. C. until the weight is constant.

Calculations:

$$\frac{\text{Weight of oil in grams} \times 1000}{17.2} = \text{grains per U. S. gal. of oil}$$

The foregoing method is used when *no* suspended matter is present, but with some waters where suspended matter *is* present with the oil, the following method is recommended.

Reagents used when second method is necessary:

Ferric Chloride solution (10 grams of iron dissolved in 200 c.c. hydrochloric acid oxidized with nitric acid and made to one liter, 1000 c.c.).

Ammonia—Chemically pure.

Procedure:

Take 1000 c.c. of the water for testing in a large beaker or flask and add 5 c.c. of the ferric chloride solution. Heat nearly to boiling, then add ammonia in excess to precipitate the iron (which precipitate contains all the oil) and boil for two minutes.

Allow to stand a few minutes and filter through a 15 centimeter filter paper, which has been previously extracted with ether, transferring the precipitate to the paper with hot water and washing three or four times with hot water. Then dry both filter and precipitate in drying oven at 90 deg. C. and when dry, extract with ether in a Soxhlet apparatus a cut of which is herewith shown. The flask of the Soxhlet apparatus should be weighed before the extraction and its weight recorded. After the extraction, the ether is evaporated to a small volume and placed in a drying oven as in method No. 1.

Calculations:

Flask with oil minus weight of empty flask equals weight of oil.

$$\frac{\text{Weight of oil in grams} \times 1000}{17.2} = \text{grains per U. S. gal. of oil}$$

The extracting of the 15 centimeter filter paper with ether, although part of the standard procedure, is not necessary where a good grade of filter paper is used.

Referring to G. G. S.'s second question, "Obtaining Condensed Steam in Per Cent of Boiler Concentrations," the method described below was used.

In all three investigations, a chemical method in place of the throttling calorimeter was used for determining the quality of steam produced. At the various observations, trap discharges were collected and examined for their content of alkaline soda and sodium chloride; thus a trap discharge free of soda and salt would mean 100 per cent dry steam, while those containing these materials indicated contamination proportionate to the percentage of boiler water contained in the trap discharge.

The content of alkaline soda was determined by taking a 100-c.c. sample of the condensed steam and titrating with N/25 (normal twenty-fifth) sulphuric acid using phenolphthalein as an indicator. The sodium chloride (salt) was obtained in a like manner by titrating with silver nitrate solution (4.97 grams per liter) using potassium chromate as an indicator.

The sodium chloride of the boiler water divided by the sodium chloride of the condensed steam gave the condensed steam in per cent of boiler concentrations.

Pittsburgh, Pa. D. C. CARMICHAEL.

Mechanical vs. Steam Atomizing

IN A HEATING PLANT, of which the writer is in charge, we have two 100-hp. externally fired, return tubular boilers with a vacuum return pump, receiving

unit and pump that operates at 20 lb. gage pressure. The fuel used is 16 deg. Baumé oil. The boilers are served by steam pressure atomizing oil burners of an old type, and natural draft. Steam for atomizing is supplied by a small vertical boiler which operates at 60 lb. gage pressure. This latter boiler is fired with coal; its furnace has a preheating air system underneath the fire box. The oil tanks are located on the outside of the power house about 8 ft. higher than the boiler room floor. Oil flows through the burner by gravity. It is heated by steam before it reaches the boiler room but never hotter than 90 deg. F. Steam generated by the main boilers is used to heat four separate buildings, one of which is 1000 ft. away.

Fairly good results from the fuel are obtainable from these boilers, for a heating plant of this capacity and no hard labor is required on the part of the operator, but there is quite a lot of tiresome loafing connected with its operation. Could a mechanical atomizing oil burner be profitably substituted for our present arrangement? B. F.

A. It is believed the change suggested would be a profitable one. A number of automatic mechanical oil burners that operate successfully are in the market. The boiler feed can also be regulated automatically so that you could not only dispense with the small boiler mentioned above but also be relieved of the necessity of being constantly present.

Problems in Electric Motors and Generators

WILL YOU kindly answer the following questions:

1. How does a shunt-wound motor act when the shunt-field is opened while the motor is running?

2. Name four causes of sparking at the brushes of a dynamo.

3. How does a short circuited field coil on a shunt-wound dynamo affect the other field coil? What causes the neutral points of a dynamo to shift when a current is flowing in the armature conductors?

4. State three reasons for the refusal of a direct current shunt-wound motor to start when the main switch is closed and the starting device is properly operated. C. B. S.

A. When the field strength of a shunt-wound motor is decreased, the motor tends to increase in speed. This is due to the fact that the speed of a shunt motor adjusts itself to the value at which the correct counter—e.m.f. for the particular load on it, will be generated. Since the value of the counter—e.m.f. is dependent upon the field strength and the speed of the armature, any decrease in field strength (the speed remaining the same), causes a decrease in the value of the counter—e.m.f. The current taken by the armature, however, is proportional to the difference between the impressed e.m.f. and the counter-e.m.f., and when the counter-e.m.f. decreases, the current through the armature becomes greater than that required by the load; consequently, the motor speeds up until the values of the counter-e.m.f. and of the impressed e.m.f. are again in correct relation for the load.

In case the field switch is opened entirely when the motor is running, this speeding up may or may not wreck the machine, depending upon the construction and characteristics of the machine and the amount of load. In any case, whether or not this armature will attain a dangerous speed, the tremendous increase in current through the armature would cause its destruction in a very short time.

2. Four causes of sparking at the brushes of a d.c. generator are: (1) Improper location, (2) Weak magnetic field, (3) Broken or short-circuited armature coils, (4) Rough commutator or brushes not properly trimmed.

3. a. A short-circuited field coil on a shunt-wound generator tends to increase the current flowing through the other field coils, causing their field strength to increase.

b. The shifting of the neutral plane in a generator when the load is applied is due to the reaction between the magnetic field of the field poles and that set up by the current in the armature. In Fig. 1 at A is shown the field due to the field current. The neutral

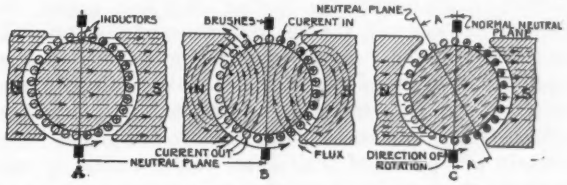


FIG. 1. SHOWING THE TWO FIELDS OF A GENERATOR WHICH CAUSE ARMATURE REACTION AND FIELD DISTORTION. A—FLUX DUE TO FIELD COIL CURRENT. B—FLUX DUE TO CURRENT IN ARMATURE. C—DISTORTED FIELD

plane, it will be seen, is vertical. At B is shown the field due to the armature current flowing alone. At C is shown the resultant of the combined fields. The original field due to the field current, it will be noted, is distorted, and the flux across the air gap is no longer uniform. This distortion shifts the neutral plane to the left as indicated.

4. Loss of residual magnetism, open circuit in the armature, reversed connections, or field coils opposed to each other.

(To be continued)

Comment on Flow of Water in Pipes

ON PAGE 697 of the June 15 issue the pressure head corresponding to 40 lb. is given as $40 \div 0.433 = 925$ ft. This should obviously be 92.5 ft. and therefore the flow given is too large.

In the formula given $Q = a\ c\ \sqrt{rs}$. As I understand it, this would be $a \times c \times \sqrt{r \times s}$ but I notice you notate it $a \times c \times \sqrt{r} \times \sqrt{s}$. I would like to have an explanation of this formula. W. J. S.

A. Your statement regarding the decimal point is correct; the pressure head corresponding to 40 lb. equals 92.5.

Assuming this figure in our equations, $92.5 \div 100 = 0.925$ and $\sqrt{s} = \sqrt{0.925} = 0.961$

$Q = 0.0888 \times 93 \times 0.29 \times 0.961 = 2.29$ cu. ft. per sec.

$2.29 \times 60 \times 7.48 = 1028$ gal. per min.

The result will be the same whether we multiply two quantities under the radical and then extract the square root or obtain the square roots of each separately and then multiply the resulting roots together. For example: in $\sqrt{a\ b}$ let us assume $a = 4$ and $b = 25$ then $\sqrt{a\ b} = \sqrt{4 \times 25} = \sqrt{100} = 10$ or $\sqrt{4} \times \sqrt{25} = 2 \times 5 = 10$.

EDITORIAL COMMENT

Organized Distribution of Public Utility Information

Public relations are rapidly becoming an important link of public utility organizations and approximately 34 committees have been organized in various states to carry on co-ordinated effort between the companies.

In Iowa, the Iowa Committee on Public Utility Information represents the electric light and power, the electric railway and the gas industries of the state. It is an information bureau organized by the various companies who are members of the committee directly, and not through different state or national associations to which they may also belong. Member companies pay a certain proportion of their gross yearly income to support the work which is directed by a governing committee of 12 men, four representing each of the three industries. Governing board members are elected for a term of one year by the presidents of the three associations interested. That is, the Iowa section of the N. E. L. A., the Iowa Electric Railway Assn., and the Iowa section of the Mid-West Gas Assn. Offices are maintained with an adequate staff in general charge of a full-time director.

The purpose of the committee is to form better public relations, maintain full contact with the public and keep the latter informed regarding the operating problems of the utilities. Advertising matter is prepared for the use of member companies and the committee gives assistance to the advertising managers of the various companies, preparing their copy and making contracts with the different newspapers. Perfect frankness is upheld and no news or advertising matter is published which cannot stand close scrutiny. As a result, there has been no criticism of the publicity or advertising matter issued so that the committee has the confidence of the newspapers and public officials of the state, and news stories relating to the utilities that are prepared and sent out by the committee to the newspapers are well received.

Through subscriptions to every newspaper in the state, close contact is made with each locality and frequently the staff is able to guide member companies from situations which might develop serious trouble. In addition, publicity for conventions is handled by getting out advance copies of the papers to be delivered, summarizing them and furnishing advance news stories to the magazines to be held for release at the proper date. Speaking engagements for men connected with the industry are arranged before colleges, high schools, civic bodies and women's clubs. The committee also gathers statistical data and special matter for the use of the member companies.

Pamphlets for school use are prepared and distributed extensively throughout the state. One of the bulletins entitled "Electricity" explains in simple language the process of generation and distribution of electricity with something about the organization, financing and operation of electric light and power companies. Another pamphlet entitled "Manufactured Gas" serves the same purpose for the gas companies.

Altogether there are about 20,000 of these bulletins now in use in the Iowa schools, in many of which the students are required to study and pass examinations on their contents. Supplementary work is arranged by getting classes to visit the electric and gas plants where the operation is explained by competent men. In this manner the committee keeps in touch not only with the adults, but looks forward a number of years and builds up good will among the coming generation, not by propaganda but by educating them to the importance of the industry and its relation to the state.

Plant Management's Responsibilities

Besides the condition of the plant and equipment, the management must be responsible for the personnel for, without an operating force which gives wholehearted co-operation, the plant and equipment will produce far less than satisfactory results. In fact, the condition of plant and equipment will depend, largely, upon that co-operation.

Present-day thought of the relations between management and workers is that they be based on equity and good will on both sides,—that the workers be treated as men and that they give of their best to secure maximum production.

On the one side is involved pay allowing the workers to be well housed, well clothed, well fed, well educated and well informed,—to be upstanding, self-reliant Americans, able to live well according to present-day standards and to save. Also the workers are entitled to such working conditions as will help in character upbuilding, since a large part of their waking hours is spent on the job.

On the other hand is involved the realization that pay can only be in proportion to the product. If production lags, costs and prices must go up and returns to employer and worker must go down for production is the only source from which returns are to be derived. This fact is accepted by the leaders among workers and is easily made clear to all. It is not important whether the production be in a longer or shorter time so long as the unit cost is not increased but workers should comprehend that only as the man-hour production improves can the man-hour pay be increased. It is part of the responsibility of management to make this understood.

Some of the factors which contribute to good relations and which should be assured by the management are peace of mind as to steady employment, comfortable surroundings, congenial and friendly associates, con-

fidence in reward for effective work. Plans or systems which will contribute to these are well worth while but should not be offered in place of wages.

Tedious and monotonous jobs, of which there must always be some in any plant, should be broken by relaxation periods or by changes between workers for the sake of safety of the worker. Replacing manual by machine operation on such work will often be economical.

After all, the job of management is to build up such proper spirit in the organization that intelligent cooperation will be secured in making the most of improved methods so as to increase production and decrease unit costs for the benefit of employer and worker.

Arranging Posterity's Affairs

"Prophets are always with us," says J. B. Priestley in a recent issue of Harper's, "but of late they seem to have been unusually active. Posterity is having its life arranged for it in every detail," he continues. "Nearly everyone who writes about the future assumes that the most marked tendencies of our own time will go on asserting themselves without ever being checked by opposing tendencies * * * If people now are depending more and more on mechanical contrivances, then the people of a century hence will be entirely dependent upon them. If our food today is largely artificial, our food tomorrow * * * will probably consist of a few chemical tabloids. If our teeth are decaying more rapidly, then our great-grandchildren will not have any teeth." And so Mr. Priestley goes on, pointing out the fallacy of drawing a curve of the present tendency in any one particular item of life and then projecting that curve forward at the same rate and in the same direction into the future.

This is sound observation and we believe that power plant engineers, who seldom deceive themselves in this way, are in a position to agree with it. The engineer often finds the above fallacy in the ideas held by the layman about the power development of the future. He finds newspaper editors, on the basis of the erection of one or two large mouth-of-mine plants, pointing out a universal tendency which will eliminate transportation of coal, lessen damage done by coal strikes and so on. He finds that the general public firmly believes that the recent increase in the development of water power shows a tendency toward the future development of every trickling stream on the continent. We might continue to pile up illustration after illustration. True, people believe these things because of ignorance or misinformation, yet the harm such beliefs can cause is no less real because of that.

The engineer, of course, knows that in the field of power it is extremely unwise to prophesy more than a few years ahead. How many engineers ten years ago foresaw the automatic hydro plant, the water-cooled wall, the 1200-lb. boiler, the 100,000-kw. turbine, the mercury-vapor cycle? It is possible to predict, with a considerable degree of certainty, as Vern E. Alden did recently, that the next two or three years will probably be marked principally by a process of refinement and consolidation of the gains made up to date. After that, however, another discovery may alter entirely some phase of power house design and send it off on a new track. If such a discovery occurs, the power plant must accept it. To project the present course of development two generations or even one generation into the future, as is often done by non-technical leaders of thought, may be interesting, but it is hardly warranted by experience. The engineer must concern himself rather with the possibilities that may arise during the comparatively short life of his present equipment.

Human nature is involved in whatever activities posterity may undertake, just as it is in ours. Judging from history, the only safe prophecy that can be made is that our great-grandchildren will find the great adventure of life in solving in their own way problems of which we cannot have the slightest conception at the present time.

How Much for Instruments?

Notable reduction in fuel cost for power generation is recorded for the country as a whole but it is certain that to a large degree this is due to improvements in the larger and more recently built plants. The average boiler plant, especially for industrial use, is not equipped with instruments which will permit of operating at the best possible efficiency or even of knowing how bad the performance is.

Such equipment is essential to economical power production. The operator must know how much fuel is used, how much power in steam and current is being produced, where and when it is being used and how this use compares with the most economical method possible.

One plant expert states that, if a plant has not instrument equipment to give these data, a definite annual appropriation of 10 per cent of the yearly fuel bill should be set aside and used for instruments, starting with those necessary to determine boiler plant performance and extending to those needed for a complete record of distribution and use of heat, light and power. This course should be continued until the plant is properly equipped to determine fuel consumption, steam flow and current supply in the generating plant and in each department of the works or factory. From such records and from cost data should be determined the cost of generating steam and current and the cost of the amounts used by each department. The plant manager should be a real executive and do an executive job.

Such records and analysis will discover loss, wastage and excess use of power and steam, so that the savings will frequently pay 20 to 30 per cent on the investment. The small plant may not be able to show as low fuel economy as the larger, more modern installation, but it should be so equipped and operated as to do the best it can, which is too often not the case at present.

THE IRON COILS used nearly 100 yr. ago by Michael Faraday, famous pioneer in electrical research, have been presented to the Franklin Institute at Philadelphia by the Royal Institute of Great Britain. Faraday was the discoverer of electro-magnetic induction. Dr. William C. L. Eglin, president of the Franklin Institute, in formally accepting the gift, declared that the coils were "priceless from a scientific standpoint and were landmarks in the research into the underlying principles of electro-magnetic induction."

N. E. L. A. Convention One of Varied Interests

EIGHT THOUSAND DELEGATES AND GUESTS DISCUSS PROBLEMS OF THE ELECTRICAL INDUSTRY AT THE FIFTIETH CONVENTION AT ATLANTIC CITY

PLEDGING ITSELF anew to the highest ideals of service, the National Electric Light Association, at its Fiftieth Convention laid plans for the accomplishment of even greater achievements than those which in the past have made this association the powerful force in the industrial, economic and social life of the nation it is today. With every division of the organization functioning with smoothness and efficiency, there is no intention on the part of those responsible for the workings of the organization to slacken their efforts to the slightest degree.

As in other late years, the most important topic of discussion and the one to which, in fact, the efforts of all branches of the N. E. L. A. are being directed was public relations. The question of public policy is a vital one. Upon the character of the public policy pursued more than upon anything else, rests the future success of the organization, and while there is no cause for apprehension at the present time, it is realized that public attitude is a fickle thing and that it may change overnight upon the slightest provocation.

To report the complete proceedings of this last convention would require a volume of some 2000 pages, so it is possible in this only to call attention to a few of the more important things discussed and in which men in the power industry are particularly interested.

Because of the enormous scope of the activities of the various sections of the organization, it has become necessary, with the exception of those held the first day of the convention, to make all sessions general sessions. On the first day, however, in addition to the opening general session held in the morning of the first day, simultaneous sessions of the Public Relations section, Engineering section, Commercial section and Accounting section were held in the afternoon.

R. F. Pack, president of the N. E. L. A. for the past year, in his opening address reviewed the early conventions of the association, contrasting the past with the present to portray more vividly the progress that had been made. Recalling that, in 1885, Mayor Carter Harrison of Chicago spoke apprehensively of electric cars as "horrid monsters," threatening death as they dashed through the streets and that the running of a car the entire length of Coney Island Pier was then a sensational exploit, Mr. Pack produced figures showing that electricity has become the great indispensable factor in the life of the nation. In 1885, the pioneers considered half-mile transmission lines of 500 v. a tremendous accomplishment. Today there are lines of 220,000 v. extending up to 500 mi.

At the first convention held at the old Grand Pacific Hotel in Chicago in 1885, Mr. Pack stated, an enthusiastic delegate moved that the proceedings be printed. Another delegate protested that there was no money in sight to pay for such printing, but the first delegate insisted that history was being made and that a record should be kept for posterity. His motion was carried. At the second convention held 6 mo. later, Summerfield Baldwin reported that $500 had been raised and that the total expenditures, including the printer's bill, amounted to only $416.17, leaving $83.83 in the treasury.

To indicate the difference in the financial condition of the association then and now, contrast the foregoing figures with those mentioned in the report of P. S. Young, treasurer, presented also at the first general session. Mr. Young reported an income for the first 10 mo. of this year of $1,178,316, which, with the balance of the previous year, made a total income of $1,785,629. Disbursements so far aggregated $943,551, leaving a balance of $842,078 available for expenses until next year's dues become available. There was a gain in membership from 15,862 last year to 17,566 this year.

In reporting on the activities of the Commercial National section, President Pack stated that they had come to a realization that the voluntary flow of business into the offices of the public service companies is not as great as formerly and that in the future it will be more necessary to go after business much as do other business concerns. This, he said, did not mean that the saturation point was reached. Far from it. There is still a

tremendous additional market awaiting intelligent sales cultivation. Splendid efforts are being made by the Commercial section in promoting proper and adequate house wiring and domestic water heating, cooking and refrigeration have all been materially advanced.

Until this year the Engineering National section has been discussing questions involving physical facts without an organization equipped to determine such facts in each case. This situation, said Mr. Pack, has now been remedied by the creation of the position of Director of Engineering at association headquarters and the entire section has been reorganized. Overlapping committees have been consolidated and useless sub-committees eliminated.

Among the speakers at the first general session on Tuesday morning were Gerard Swope, president of the General Electric Co., and M. H. Aylesworth, former managing director of the N. E. L. A., but now president of the National Broadcasting Co., Inc. Mr. Swope addressed the convention as the representative of the National Electric Manufacturers Association of which he is president. He outlined the scope, work and hopes of this infant organization, which is not yet one year old, and its relation to the electrical industry. The problem of an electrical manufacturers' association, said Mr. Swope, is somewhat more difficult than that of the N. E. L. A. in that the electrical manufacturers, who are the members, compete with each other in almost every locality, state, nationally and internationally. The matters that may concern all are limited by personal considerations, often selfish and by law.

Mr. Aylesworth in his address predicted that in a short time the electrical energy consumption through radio equipment will be a vital part of electric public utility service. Fifty million new lamps, he said, will be burning in the daytime, not in competition with sunlight but hidden away in the form of tubes in radio sets and auxiliary equipment.

Engineering Progress Reported on by Engineering Section

Among the more interesting reports presented at the session of the Engineering National section, at which C. F. Hirshfeld presided, were those of the electrical apparatus committee, the hydraulic power committee, the overhead and underground systems committees and the prime movers committee. Mr. Hirshfeld emphasized two things at this session which typify the policy and actions which inspire engineers to renewed efforts to build the electric light and power industry. There has come about a closer co-ordination of effort and a broader outline of engineering policy whereby only the major tasks are undertaken by national committees. Economic and social phases have been brought into the picture and are being weighed in connection with the work of the engineers. The second thing dealt with the fact that engineering progress means that engineers must think and work in terms of science of tomorrow and not of yesterday.

In this latter connection, a timely paper was presented at this session by L. A. Hawkins of the General Electric Co. on "Today's Science and Tomorrow's Engineering." Mr. Hawkins stressed the fact that the engineers of today face a period of radical and rapid development whereby old ideas and old practices may be discarded or materially changed.

In sketching briefly the history of electrical science, Mr. Hawkins discussed the effect of the new physics upon what were always considered fundamental truths, but about which we now have to form new ideas. Electricity, he said, has always been regarded as the most mysterious force and unknowable thing in the universe next to life itself. Yet, today, it may be fairly well said that we know more fully what electricity is than we know the true nature of anything else, and that most of modern physics and physical chemistry consists of the effort to explain everything else, even life itself, in terms of the one thing we most fully know—electricity.

The electron and the device by which we have come to know it best, said Mr. Hawkins, is to play an ever increasingly important role in engineering. Already the electron tube is creeping into the power field for communication and control. And the tubes are steadily growing. They give promise not merely of controlling but of transmitting power in bulk. High voltage tubes have been built to operate successfully on 500,000 v. High current tubes have passed as high as 600 amp. Were it possible to combine both capacities in one tube we should have a rating of 300,000 kv.a. Such a combination is now and may always be impracticable, but we should not have to go beyond one per cent of that rating to have a real power tube. When such a stage is reached, the logical function of the electron tube would be as a converter from a. c. to d. c. and back again.

H. L. Doolittle, chairman of the hydraulic power committee, reported the average time of the outage of hydraulic turbine units with regard to the time of demand as 1¾ per cent. Progress, he said, has been made in all branches of hydraulic power work. One interesting development was the use of seamless steel forgings for the lower sections of high head penstocks. Some of these sections are machined inside and out and weigh 25 t. each.

The hydraulic turbines at Muscle Shoals, he said, attained an efficiency of 93.1 per cent.

E. B. Ricketts, who presented the report of the Prime Movers committee in the absence of chairman A. D. Bailey, indicated the promotion from the experimental grade to that of sound engineering of a number of new departures in power plant practice. Among the more important of these are the 1200 and 1400-lb. boiler and turbine installations, the turbine operating on the mercury vapor cycle, and the application of extensive water cooling to boiler furnaces. While each one of these accomplishments brought us a step nearer the ideal of power plant efficiency, there are still more worlds to conquer. It must be remembered, said Mr. Ricketts, that the most efficient system of today converts only about one-third of the coal's potential energy into electricity.

In the field of electric apparatus, progress was indicated in all directions. In the report of the committee dealing with this division of the field, H. R. Woodrow showed that the work of this committee was being carried out with the following factors in mind: 1. Principles of system connections and inter-system connections. 2. Voltage standardization. 3. Protective schemes 4.

System stability. 5. Isolation of supply sources. 6. Phase isolation. 7. Load control.

Secretary Davis Outlines National Defense Plan

On Wednesday, June 8, at the morning general session, the convention was addressed by the Hon. Dwight F. Davis, Secretary of War. Mr. Davis paid great tribute to the electrical industry and indicated how vitally important a factor it was in the nation's defense program. He outlined a plan, which has been worked out, to provide co-ordination of the electrical industry with all other agencies of national defense in time of emergency.

An always welcome speaker at the conventions of the N. E. L. A. is B. C. Forbes, editor of Forbes Magazine and the donor of the Forbes Magazine Award in the Public Relations Contest. This prize, which is presented to the power company which, in the opinion of the judges, has done the most in obtaining better public relations, this year goes to the Georgia Power Co. In his presentation speech, Mr. Forbes pointed out the need for constant effort in public relations work and that if the public is to continue to invest its savings in the public utility companies, the companies must gain and hold its confidence. The fact that electricity in the face of rising prices is now sold at a lower cost than ever before, said Mr. Forbes, is tremendously to the credit of the companies.

Public Policy Session

Perhaps the most important meeting of the week, so far as attendance was concerned, was the Public Policy session held Wednesday night, June 8, in the ballroom of Young's Million Dollar Pier. Thousands were present to hear the report of the public policy committee and to witness the award of the Coffin medal for meritorious service to the industry to the Edison Electric Illuminating Co. of Boston. At this meeting, a comprehensive address was delivered by a former Cabinet officer, Hon. David F. Houston, upon the relation of business to government. The proceedings which included music by George Olsen and Orchestra and a number of songs by Mario Chamlee, tenor of the Metropolitan Opera Co., were broadcast throughout the country by courtesy of the National Broadcasting Co.

The Coffin award was presented by President Pack to Charles L. Edgar, president of the Edison Electric Illuminating Co. of Boston. In his address Mr. Pack pointed out the varied and far-sighted contributions to the welfare of the public and the good of the industry which have been achieved in engineering development, commercial activity, public and trade relations by this most important of New England central station companies.

Manufacturers' Exhibits

As in other years, a splendid exhibit of manufacturers' equipment was held on Young's Pier in connection with the convention. While the majority of exhibits were of interest to the merchandising men there were a considerable number of interest to engineers. Actual working devices, models, cut away sections, photographs, drawings, moving pictures all played their part in presenting to the delegates a clear picture of development in all branches of the electrical industry.

In all, there were 195 exhibits as compared with 184 last year and 138 in the one previous. A diversified line of power equipment was on display. High tension switch gear commanded great attention as did air circuit breakers—one firm exhibiting a 6000-amp. solenoid operated air circuit breaker for use on voltages below 550. Several exhibits of self-ventilated motors were shown. Other displays featured tap changing equipment for changing the ratio of transformers under load, carrier current apparatus, varying frequency telemetering, pulverized coal burning equipment, soot blowers, combustion control apparatus, turbo-generators, pumps, water softening apparatus, etc.

One of the most interesting of the papers presented at the session held Thursday, June 9, was that entitled "Electricity, the Slave of the Lamp," by Bancroft Gherardi, vice-president of the American Telephone and Telegraph Co. and president-elect of the American Institute of Electrical Engineers. Mr. Gherardi told of how the story of Aladdin and the lamp thrilled him when he was a boy and the regret he experienced when he realized that the story could not be true. Little do we realize, said Mr. Gherardi, that as we accept as a matter of course what electricity does for us every day, that if those who wrote these legends could see what electricity does for us today they would regard these services far more wonderful than those in the tales of imaginative literature. He then described the history of electrical development and pointed out the possibilities of the future in his usual interesting manner.

Other speakers Thursday were W. H. Onken, Jr., editor of the Electrical World; Frank W. Smith of The United Electric Light and Power Co.; P. S. Arkwright, Georgia Power Co.; Mrs. John D. Sherman, president of the General Federation of Women's Clubs; Charles E. Mitchell, president of the National City Bank of New York; D. F. Kelly, president of The Fair, Chicago, Ill., and W. W. Freeman, vice-president of the Columbia Gas and Electric Co.

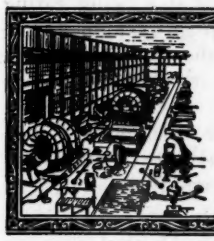
One of the last important addresses listened to by the delegates was that by the Honorable Albert C. Ritchie, Governor of Maryland, on Friday morning. This was the concluding event on the program. The following officers were elected to carry on the work of the association: President, H. T. Sands, Electric Bond & Share Co., New York, N. Y.; vice-presidents: 1st, P. S. Arkwright, Georgia Power Co., Atlanta, Ga.; 2nd, John B. Miller, Southern California Edison Co., Los Angeles, Calif.; 3rd, M. S. Sloan, Brooklyn Edison Co., Inc., Brooklyn, N. Y.; 4th, W. A. Jones, Henry L. Doherty & Co., New York, N. Y.; treasurer, P. S. Young, Public Service Electric & Gas Co., Newark, N. J.

National Executive Committee, Members-at-Large, Term Expiring June 30, 1928

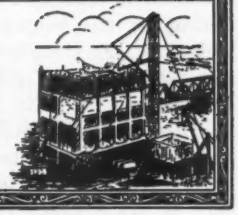
R. F. Pack, ex officio, Northern States Power Co., Minneapolis, Minn.; George E. Gullinan, Graybar Electric Co., New York, N. Y.; James R. Strong, Tucker Electrical Construction Co., New York, N. Y.

Term Expiring June 30, 1930

D. C. Barnes, Stone & Webster, Inc., Boston, Mass.; H. P. Liversidge, The Philadelphia Electric Co., Philadelphia, Pa.; Gerard Swope, General Electric Co., New York, N. Y.

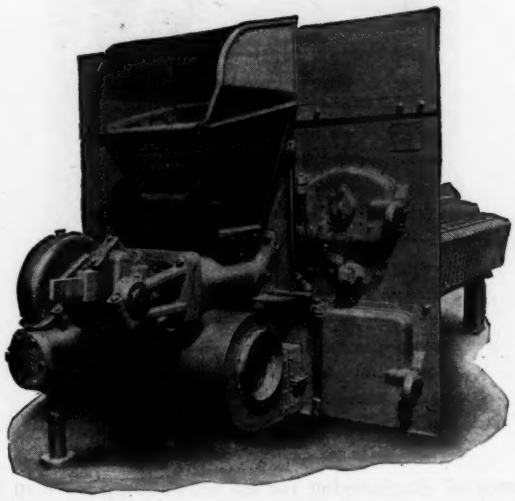


POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



UniStoker Has Self-Contained Fan

DERIVING ITS NAME from its unit design, the recently announced UniStoker is now being marketed. Each boiler and stoker of this type make up a complete and independent unit, in conformity with the present trend in modern engineering practice toward independent units in all important items of power plant equipment. An electric motor, direct connected to the gear case, and to a forced draft fan located conveniently at the front, as shown in the illustration, comprises the operating mechanism of this stoker. The compact design of the UniStoker, as well as the elimination of auxiliaries on the side of the boiler, are intended to save floor space and make it particularly adaptable to small and medium sized boilers. Little or no excavation or concrete work are necessary in installing it.



MOTOR FURNISHES POWER FOR STOKER AND FAN SHOWN BELOW HOPPER, THUS SUPPLYING AIR IN PROPORTION TO FUEL BURNED

Cleaning is effected by means of an ash dump on each side operated by hand. Refuse is first wet down from water spray pipes located in the ashpits, then removed through the ashpit doors in front.

When equipped with the UniStoker, no more power is used than is required for the number of stokers in actual operation, even when several boilers are set in battery, since each boiler is an independent unit.

The quantity of air is in direct proportion to the fuel burned, at all boiler ratings, as the motor is direct connected to both the stoker drive and the fan. Long runs of piping and air ducts are eliminated, inasmuch as the fan discharges directly into the stoker air chamber. Distribution of air from the fan is effected to keep all parts of the fuel bed active. Air under control is likewise admitted through the grate bar sections of the dumps to prevent loss of combustible in the ash.

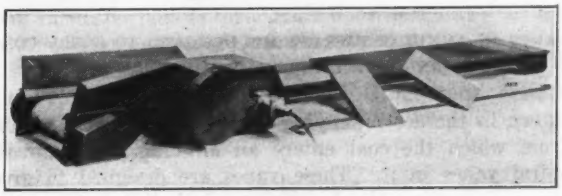
Provision is made for uniform delivery of fuel below the fire through the entire length of the retort. Adjustments are provided to govern the length of travel of the ram, which can be regulated from full stroke to no stroke. Auxiliary pusher bar and blocks provided at the bottom of the retort are adjusted independently, so that their stroke accords with the feed of the fuel. No moving parts are exposed to the fire. All grates, tuyeres and dump plates are designed in interlocking sections, to be interchangeable and easily removed.

Mechanical drive used on the UniStoker comprises a combination of two sets of machined worms and gears, with worms cut from steel drop forgings and equipped throughout with Timken anti-friction tapered roller bearings. All worms and gears run in oil and are completely enclosed in gear case, as protection from dirt and dust.

The UniStoker, made by the Detroit Stoker Co., Detroit, Mich., is, in effect, a modification of the Detroit single retort stoker.

Portable Unloader for Hopper Bottom Cars

UNLOADING OF SAND, gravel, crushed stone, coal, coke and similar materials from hopper bottom cars without the use of a pit or trestle is the problem that a new portable unit, The X-Track-Tor, is designed to solve. To do this, a specially protected belt is employed instead of the usual heavy double strand of chain and scraper flights. The design is also intended to lessen breakage of coal handled by the unit. It is intended for use with large lump coal as well as with the smaller sizes or with sand, gravel and so on. The



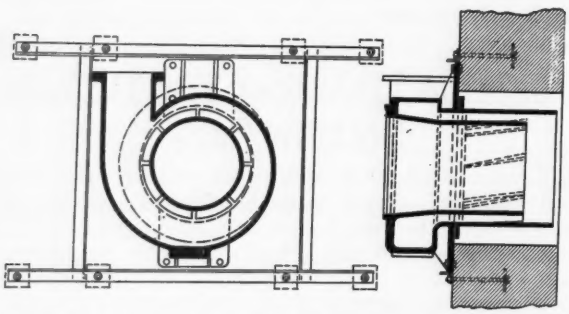
BELT CONVEYOR RESTS ON RAILS UNDER CAR HOPPER AND CAN BE DRIVEN BY ENGINE OR MOTOR

X-Track-Tor, shown in the accompanying illustration, rests over the rails under the hopper of the car. It is intended to take up a space of only 2¾ in. between the bottom of the hopper and the top of the rail. The weight of the complete machine is a little over 600 lb. but the motor and other parts are detachable, leaving the heaviest pieces to handle about 450 lb.

In operation, the flow of the material from the car is regulated by the hopper opening and by removable cover plates over the belt. No other regulation is necessary as the X-Track-Tor is designed to work when completely buried in material and its capacity is governed only by the capacity of the secondary unit to which it delivers. As the material flows out of the car, the removable cover plates are removed, permitting the X-Track-Tor to empty all the material from the farthest side of the car hopper. When unloading from a car having several hoppers, the machine can be moved along the rails to the next hopper position or the car may be pinched along the track to accomplish the same purpose. The X-Track-Tor is built with either a gasoline engine or an electric motor, detachable for convenience in handling. The machine may be operated from the ordinary electric light current. The conveyor is 13 ft. long and 20 in. wide overall. A 16-in., 3-ply rubber covered belt is used. The unit is being placed on the market by The Jeffrey Mfg. Co., Columbus, Ohio.

New Centrifix Pulverized Coal Burner

DEVELOPMENT of turbulent pulverized coal burners has brought out many new designs, among them the new BB Centrifix Burner as developed by the Furnace Engineering Co., New York City. This burner,



VANES IN ANNULAR PASSAGE ARE DESIGNED TO SWIRL COAL AND GIVE UNIFORM DISTRIBUTION

shown in the accompanying sketch, consists of a volute from which the coal enters an annular passage with spiral vanes in it. These vanes are designed to give the coal leaving the burner a spiral diverging action with a uniform distribution of coal around the burner tip. To secure this uniform distribution a properly designed volute must be used that assures equal pressures throughout the burner.

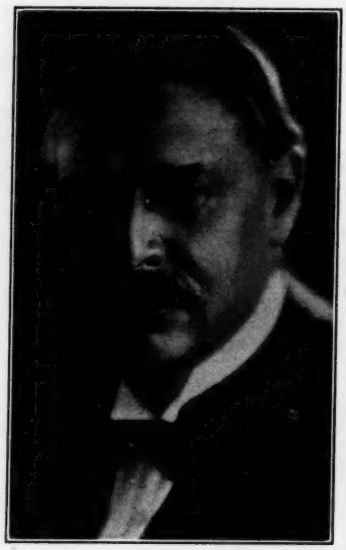
Design of the burner also permits aspiration of air through the center of the burner. This aspiration, as tests have showed, equals approximately 35 per cent of the air delivered to the burner by the fan.

Recent tests with the induced draft type of these burners, installed by the Ohio Public Service Co. showed a liberation of 20,000 B.t.u. per cubic foot of furnace volume. The flame length was 8 ft. at a boiler rating of 220 per cent. Operation at ratings as high as 270 per cent have been obtained with the flame length not exceeding 10 ft. The furnaces were total refractory without water cooling.

These burners are designed for both induced and forced draft. They also may be used with pulverized coal in combination with oil or gaseous fuels.

Dr. George Clinton Ward

GEORGE CLINTON WARD, vice-president in charge of engineering and construction for The Southern California Edison Co., has been honored by the University of Southern California with the honorary degree of



Doctor of Engineering for his outstanding work in this field. This is one of the rarest of all honorary degrees. Out of 700 honorary degrees granted last year by all the universities and colleges of the country, only seven men received the engineering doctorate. In the audience at the commencement day exercises on June 4, more than 1000 Edison employes were gathered to see the honor conferred.

Mr. Ward began his engineering career in New York State following his graduation from Phillips Andover Academy. As chief engineer for the Raquette Lake Railway, he attracted the attention of Collis P. Huntington and, as a logical sequence, became associated with the late Henry E. Huntington when the latter began his work as an empire builder in Southern California.

Looking about for an additional power supply for his electric railroad interests, Mr. Huntington commissioned Ward to make a hydro-electric development in the High Sierra of Fresno County, which was the beginning of the Edison Co.'s famous Big Creek-San Joaquin project. The most notable feature of this undertaking is the Florence Lake tunnel, completed in 1925, 14 mo. ahead of schedule. This tunnel, 13 mi. in length, is the longest water tunnel of its bore in the world. It diverts the rainfall of the Florence Lake watershed into Huntington Lake, making it available for the four powerhouses of the Edison Co. now in service as well as for others that are to be constructed.

Death of General Tripp, Westinghouse Chairman

BRIGADIER GENERAL GUY E. TRIPP, chairman of the board of directors, Westinghouse Electric and Manufacturing Co., died Tuesday evening, June 14, in the New York Hospital, New York. Death was due to complications following an operation.

Guy Eastman Tripp was born in Wells, Maine, April 22, 1865. He was educated at South Berwick (Maine) Academy, and at the age of 18 entered the employ of the Eastern Railway Co. as a clerk. In 1890 he became storekeeper for the Thompson-Houston Electric Co. and

shortly afterwards traveling auditor. In 1897 he became associated with Stone & Webster, Inc., occupying successively important positions until he was elected vice-president of the Stone & Webster Management Association and also of the Stone & Webster Engineering Corp. In 1912 he was elected Chairman of the Board of Directors of the Westinghouse Electric & Manufacturing Co., in which capacity he has continued to date.

Shortly after the United States entered the World War, Mr. Tripp was selected for Chief of the Production Division of the Ordnance Department, U. S. A., because of his intimate knowledge of manufacturing and his broad executive experience. He entered the service in January, 1918, and within 10 mo. was made a Brigadier General and Assistant to the Chief of Ordnance of the United States Army. Upon leaving the service immediately after the Armistice, he was awarded the Distinguished Service Medal for "particularly meritorious service."

In the past few years Mr. Tripp has manifested an especially keen interest in the future of electrical development in America. His articles and addresses on power development attracted wide attention. On June 18, 1924, Bates College, Lewiston, Maine, conferred on him the degree of LL.D., in recognition of his many accomplishments.

General Tripp was director in many industrial organizations, was a trustee of South Berwick (Maine) Academy, member of many clubs, and member of many national scientific and technical societies.

A. S. H. & V. E. Meets at White Sulphur Springs

RESULTS OF MANY investigations in the heating and ventilating field during the past six months were reported by various members and committees at the 33rd Semi-Annual Meeting of American Society Heating and Ventilating Engineers held at the Greenbrier Hotel, White Sulphur Springs, W. Va., from June 28 to 30.

A committee headed by Alfred Kellogg reported on the Code for Rating Low Pressure Heating Boilers. F. M. Holbrook discussed the design and performance of an office building heating plant. Results of investigations of cast iron radiator performances in various enclosures were reported by Prof. A. P. Kratz and M. K. Fahnestock. Recent developments in direct connected fans and blowers was discussed by A. G. Sutcliffe and development of extended surface heating units was presented by R. N. Trane.

Convention sessions were interspersed with special recreational features, such as golf tournaments, dancing, and the other usual recreations of White Sulphur Springs.

News Notes

COCHRANE CORP., Philadelphia, Pa., announces the appointment of the Paul B. Huyette Co., Inc., 5 South 17th St., Philadelphia, as its representative in the sale of Cochrane flow meters in Western Massachusetts, Connecticut, Eastern New York, Eastern Pennsylvania, New Jersey, Delaware and Eastern Maryland.

THE DAMPNEY CO. OF AMERICA, Hyde Park, Boston, Mass., announces that sales of its Apexior protective coatings for power plant equipment will be handled in the Detroit district by Coon-DeVisser Co., 2051 Lafayette Blvd., Detroit, Mich., in the Cleveland district by A. MacLachlan Co., Union Trust Bldg., Cleveland, O., and in the Milwaukee district by Fred H. Dorner, 548 Milwaukee St., Milwaukee, Wis.

C. C. Moore & Co. with offices in San Francisco, Los Angeles, Portland, Seattle, Phoenix and Salt Lake City will in future handle the Pacific Coast territory business of the Dampney Co. of America.

The company has also appointed Arthur T. Hunter as its representative for southern Illinois and eastern Missouri, with headquarters at 2083 Railway Exchange Bldg., St. Louis.

JENKINS BROS., New York, announces with regret the retirement of Arthur C. Langston as an active representative of the company.

KENNEDY VALVE MFG. CO. has moved its Chicago branch and warehouse to 1335-1337 South Clinton St., in the new Soo Terminal, Chicago, Ill.

BRIDGEPORT BRASS CO., Bridgeport, Conn., has appointed Robert T. Kent, until recently Superintendent of Prison Industries, State of New York, to the position of general manager of the company.

CHAIN-BELT Co., Milwaukee, Wis., announces that T. E. Cocker, for 6 yr. district manager of its Buffalo office, is now in charge of its Cleveland office at East 200th St. and St. Clair Ave.

C. J. TAGLIABUE MFG. Co., Brooklyn, N. Y., has opened a branch factory at 5902 Carnegie Ave., Cleveland, O., in charge of the district manager, A. R. Anderson.

WM. B. SCAIFE & SONS Co., Oakmont, Pa., announces with regret the death of its superintendent, G. A. Meckel, on May 16. On May 26 of this year, Mr. Meckel would have completed 64 yr. of continuous service with this company, of which 51 were served as general superintendent.

BAILEY METER Co., Cleveland, O., announces the appointment of E. W. Fitch as Manager of its St. Louis office, at 1808 Railway Exchange Bldg., St. Louis. Mr. Fitch was formerly engaged in field work in connection with Bailey combustion control equipment in the New England States.

THE AUSTIN Co., Cleveland, O., engineers and builders, has opened a branch office in Cincinnati, O., in charge of H. L. Cornelison until recently manager of the Miami office. The new Cincinnati office is located on the 6th floor of the Dixie Terminal Bldg. On May 1 the Chicago headquarters of the Austin Co. moved to 510 N. Dearborn St.

Books and Catalogs

THE "MECHANICAL WORLD" ELECTRICAL POCKET BOOK for 1927, 400 pages, 4 by 6, cloth, 40c, London.

This little book, like its many predecessors, is always welcome. While the general subject matter is similar to that contained in the handbooks of other years a number of new features have been added, particularly to the section on alternating current commutator motors.

Another section which is new deals with time switches and electric signs, flashers and dimmers. These sections include discussions of the most recent designs of control appliances and contain many relevant data which will be found of service in connection with the installation of this equipment.

In addition to the information on various types of electrical equipment, its theory and operation, there are included a number of mathematical tables which will prove of value to every engineer.

REMODELING of Unit No. 2 in the Fordson plant of the Ford Motor Co. is described and the results attained are given in a booklet issued by the International Combustion Engineering Corp., Madison Ave. and 35th St., New York, N. Y. Starting with a boiler having 26,470 sq. ft. of heating surface, which operated at 250 per cent of rating but whose capacity was outgrown by the plant, the furnace was enlarged and the walls lined with steam generating tubes and equipped with radiant superheaters. Arch water screens and bottom water screens were added, the additions constitute an independent steam generating unit delivering steam to the same distribution system as the original boiler.

Front walls are air cooled, secondary air being supplied through ports under pressure, also air preheaters and induced draft fans are provided above the boilers.

Performance shows an output of 16,000 to 16,500 hp., the addition of 12 per cent of water heating surface and rebuilding of the furnace, increasing steaming capacity 100 per cent so that the unit now delivers 600 per cent of the rating of the original boiler.

Details and illustrations of the remodeling and of performance before and after are given in the booklet which may be obtained by writing to the International Engineering Combustion Co. Other units in the plant are being remodeled on the same plan.

PAMPHLET No. 8, entitled "A Treatise of an Interesting Heat Treatment of Boiler Feed Water" has been published by The First Engine & Boiler Insurance Co., Ltd., of Tokyo, Japan, for the purpose of advising Japanese steam users of methods of generating high pressure steam. The pamphlet, prepared by Sojiro Haga, chief engineer of the company, describes and discusses private investigations and describes, by means of reprints, the Atmos high pressure boiler and the 1200-lb. installations of Weymouth Station.

DAMPNEY Co. OF AMERICA, Hyde Park, Boston, Mass., is issuing a new price list of Apexior products which can be had by writing to the above address.

HARNISCHFEGER CORP., Milwaukee, Wis., in Bulletin BF-1 describes P & H backfillers, Model-35. These are driven by Waukesha gasoline engines and have a boom of latticed construction adjustable between 22 and 31 ft.

SIROCCO BLOWERS for oil burners are described in Bulletin No. 1033 issued by American Blower Co., Detroit, Mich. These are used in connection with domestic oil burners. For industrial burners, a different type of blower is designed to furnish a higher air pressure.

THE PULVERBURNER, a complete mechanism of the unit type for firing powdered coal is described in a new 16-page well-illustrated bulletin issued by Illinois Stoker Co., Alton, Ill. Discussion is given of the construction and operation of the Pulverburner, together with interesting installation photographs and records of performance.

IN BOOK No. 666, Link-Belt Co., Chicago, Ill., describes the Link-Belt power hoe. This is an improved form of drag scraper in which the scraper or hoe is made of such construction that the scoop digs into the material until the top plate comes down on the material, thus preventing it from digging any more deeply, while the sides act as guides and hold in the load. This is designed to prevent overload on the operating mechanism. The bulletin is well illustrated with photographs of the equipment in operation.

RILEY SUPER-STOKERS are described in a 36-page well-illustrated bulletin issued by Riley Stoker Corp., Worcester, Mass. This is a stoker designed for large stations, to operate at maximum efficiency at the highest boiler rating. Photographs and drawings of installations are presented, together with diagrams showing details of installations and sizes. The stoker is made up to 21 ft. 11 in. in length. It is furnished either with double or single roll clinker grinders, or with rocker dumps.